Total Maximum Daily Load (TMDL) Status Report
Rosebud Creek TMDL Planning Area

March 14, 2003

Department of Environmental Quality

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Prepared for the Montana Department of Environmental Quality by Tetra Tech, Inc.
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TABLE OF CONTENTS

1.0 Introduction 1
1.1 Background 1
1.2 Document Purpose and Content 3
1.3 Future Phases 3
1.3.1 Phase II – Interim Framework TMDL's 3
1.3.2 Phase III – Final TMDL's 4
2.0 Watershed Characterization 5
2.1 Physical Characteristics 5
2.1.1 Location 5
2.1.2 Climate 5
2.1.3 Hydrology 10
2.1.3.1 Rosebud Creek Flow Data - Main Stem 10
2.1.3.3 Stream Types 11
2.1.3.4 Irrigation Practices 13
2.1.4 Groundwater 13
2.1.5 Topography 13
2.1.6 Major Land Resource Areas 16
2.1.7 Land Use and Land Cover 16
2.1.8 Vegetative Cover 18
2.1.9 Soils 21
2.1.9.1 Universal Soil Loss Equation (USLE) K-factor 22
2.1.9.2 Hydrologic Soil Group 22
2.1.9.3 Permeability 25
2.1.9.4 Salinity 25
2.1.9.5 Sodium Adsorption Ratio 28
2.1.9.6 Clay Content 28
2.1.10 Riparian vegetation characteristics 31
2.2 Cultural Characteristics 32
2.2.1 Population 32
2.2.2 Land Ownership 33
2.2.3 Economics 35
2.3 Fisheries 36
3.0 Water Quality Concerns and Status 38
3.1 Montana 303(d) List Status 38
3.2 Parameters of Concern 40
3.2.1 Salinity and Total Dissolved Solids 40
3.2.2 Chlorides 40
3.2.3 Sodium Adsorption Ratio 41
3.2.4 Nutrients/Organic Enrichment/Low Dissolved Oxygen 42
3.2.5 Metals 42
3.2.6 Total Suspended Solids 43
3.2.7 Other Inorganics (Sulfate) 43
3.3 Applicable Water Quality Standards 43
3.3.1 Montana Standards 44
3.3.1.1 Narrative Standards 44
3.3.1.2 Numeric Standards 45
3.3.1.3 Petitioner Standards 47
3.3.1.4 Use Support Guidelines 47
3.3.2 Northern Cheyenne Standards 48

3.4 Rosebud Creek Water Quality Impairment Status 50
3.4.1 Macroinvertebrates and Periphyton 52
3.4.2 Fish 52
3.4.3 Water Chemistry Assessment 52
3.4.3.1 Salinity 54
3.4.3.2 Total Dissolved Solids 60
3.4.3.3 Chlorides 64
3.4.3.4 SAR 66
3.4.3.5 Metals 70
3.4.3.6 Total Suspended Solids 71
3.4.3.7 Nutrients 73
3.4.3.8 Other Inorganics (Sulfate) 78
3.4.3.9 Water Quality Impairment Status: Rosebud Creek 81
4.0 Conceptual Monitoring Plan 83
4.1 Identified Data Gaps 83
4.1.1 Beneficial Use Determinations 83
4.1.2 Model Calibration 83
4.1.3 Source Assessment 84
4.2 Monitoring Strategy 85
4.2.1 Data Gap – No Current Data 85
4.2.1.1 Tributaries 85
4.2.1.2 Rosebud Creek 85
4.2.2 Data Gap – Sources 88
4.2.2.1 Irrigation Return Flows 88
4.2.2.2 Mining 88
4.2.2.3 Streambank Erosion 88
4.2.2.4 Other Potential Sources 89
4.2.2.5 Continuous Data Monitoring 89
References 90
Appendix A: Major Land Resource Areas Data Description A-1
Appendix B: Multi-Resolution (MRLC) Land Characteristics Consortium Data Description B-1
Appendix C: Montana Narrative Water Quality Standards C-1
Appendix D: MDEQ Proposed EC and SAR Standards D-1
Appendix E: Comparison of the Proposed EC and SAR Standards E-1
Appendix F: Coefficients for Calculating Metals Standards for Surface Waters F-1

TABLES

Table 2-1. NOAA climate stations located in the Rosebud Creek watershed. 8
Table 2-2. Selected USGS stream gages for Rosebud Creek. 10
Table 2-3. Summary of stream type in the Rosebud Creek watershed. 12
Table 2-4. Surface water uses designated by water rights. 13
Table 2-5. Land use and Land cover in the Rosebud Creek watershed. 18
Table 2-6. Vegetative cover according to GAP analysis for the Rosebud Creek watershed. 20
Table 2-7. Hydrologic Soil Groups. 22
Table 2-8. Vegetative characteristics within the riparian corridor of Rosebud Creek. 31
Table 2-9. Rosebud Creek watershed population summarized by county. 32
Table 2-10. Urban population centers in the Rosebud Creek watershed. 32
Table 2-11. Land Ownership in the Rosebud Creek Watershed. 33
Table 2-12. Summary of population and work force data per county. 35

Table 2-13. Unemployment rates by county and reservation. 35
Table 2-14. Percent employment by sector in 2000.... 36
Table 2-15. Summary of agricultural economics data for 1997.... 36
Table 2-16. Fish species in Rosebud Creek. 37
Table 3-1. 1996 listing information for Rosebud Creek. 38
Table 3-2. 2002 listing information for Rosebud Creek. 38
Table 3-3. Summary of the Montana narrative water quality standards and affected pollutants..... 45
Table 3-4. Montana surface water quality standards for all waters in the state. 46
Table 3-5. Aquatic life standards for DO (mg/L). 46
Table 3-6. Montana DEQ proposed EC (µS/cm) standards for agricultural uses. 47
Table 3-7. Petitioner proposed EC and SAR standards. 47
Table 3-8. Northern Cheyenne surface water quality standards. 49
Table 3-9. Numeric standards for EC, TDS, and SAR for waters in the Northern Cheyenne Reservation..... 49
Table 3-10. Water quality impairment status summary. 51
Table 3-11. Summary of EC data, Rosebud Creek (µS/cm) (November 1–March 31). 55
Table 3-12. Summary of EC data, Rosebud Creek (µS/cm) (April 1–October 31). 55
Table 3-13. Summary of EC exceedances, lower Rosebud Creek.... 56
Table 3-14. Summary of EC exceedances, middle Rosebud Creek.... 56
Table 3-15. Summary of EC exceedances, upper Rosebud Creek.... 57
Table 3-16. Proposed EC standards and calculated TDS targets. 61
Table 3-17. Summary of TDS data, Rosebud Creek (mg/L) (November 1–March 31).... 61
Table 3-18. Summary of TDS data, Rosebud Creek (mg/L) (April 1–October 31). 62
Table 3-19. Summary of chloride data, Rosebud Creek (mg/L) (November 1–March 31). 65
Table 3-20. Summary of chloride data, Rosebud Creek (mg/L) (April 1–October 31). 65
Table 3-21. Summary of SAR data, Rosebud Creek. 67
Table 3-22. Summary of SAR exceedances, lower Rosebud Creek 67
Table 3-23. Summary of SAR exceedances, middle Rosebud Creek 68
Table 3-24. Summary of SAR exceedances, upper Rosebud Creek 68
Table 3-25. Average concentrations (mg/L) in the lower Rosebud Creek.... 68
Table 3-26. Summary of TR metals data at station 06296003, lower Rosebud Creek (1996-2002). 70
Table 3-27. Summary of TSS data, Rosebud Creek (mg/L). 71
Table 3-28. Guidelines for nutrient criteria from various states. 73
Table 3-29. Summary of total phosphorus data, Rosebud Creek (mg/L). 74
Table 3-30. Summary of total nitrogen data, Rosebud Creek (mg/L).... 74
Table 3-31. Summary of nitrite/nitrate data, Rosebud Creek (mg/L). 75
Table 3-32. Summary of DO data, Rosebud Creek (mg/L). 75
Table 3-33. Summary of sulfate data, Rosebud Creek (mg/L) (November 1–March 31). 78
Table 3-34. Summary of sulfate data, Rosebud Creek (mg/L) (April 1–October 31). 79
Table 3-35. Water quality impairment status summary. 82
Table 4-1. Identified data gaps in the Rosebud Creek watershed. 84
Table 4-2. Pollutants and their potential sources in the Rosebud Creek watershed.... 85
Table 4-3. 2003 metals sampling sites for the main stem Rosebud Creek.... 86
Table D-1. August 29, 2002 proposed EC standards for agricultural uses (µS/cm). D-2
Table D-2. December 6, 2002 proposed EC standards for agricultural uses (µS/cm). D-2
Table D-3. December 6, 2002 proposed SAR standards for agricultural uses.... D-2
Table E-1. Summary of EC exceedances, lower Rosebud Creek. E-3
Table E-2. Summary of EC exceedances, middle Rosebud Creek. E-3
Table E-3. Summary of EC exceedances, upper Rosebud Creek. E-3
Table E-4. Summary of SAR exceedances, lower Rosebud Creek.... E-5
Table E-5. Summary of SAR exceedances, middle Rosebud Creek.... E-5

Table E-6. Summary of SAR exceedances, upper Rosebud Creek. E-5
Table F-1. Coefficients for calculating metals standards in Montana. F-2
Table F-2. USEPA equations and conversion factors for metals. F-2

FIGURES

Figure 2-1. Location of the Rosebud Creek watershed. 7
Figure 2-2. Distribution of NOAA climate stations in the Rosebud Creek watershed. 8
Figure 2-3. Climagraph for Busby, MT, station 241297. 9
Figure 2-4. Climagraph for Colstrip, MT, station 241905. 9
Figure 2-5. Location of selected USGS stations in the Rosebud Creek watershed. 10
Figure 2-6. Average daily flows at three USGS gages on the main stem of Rosebud Creek (entire period of record is shown). 11
Figure 2-7. Stream types in the Rosebud Creek watershed. 12
Figure 2-8. Elevation in the Rosebud Creek watershed. 14
Figure 2-9. Shaded relief of the Rosebud Creek watershed. 15
Figure 2-10. Land use and Land cover in the Rosebud Creek watershed. 17
Figure 2-11. Vegetative cover in the Rosebud Creek watershed. 19
Figure 2-12. General soil units for the Rosebud Creek watershed. 21
Figure 2-13. Distribution of the USLE K-factor. 23
Figure 2-14. Distribution of hydrologic soil groups. 24
Figure 2-15. Distribution of soil permeability. 26
Figure 2-16. Distribution of soil salt concentrations in the Rosebud Creek watershed. 27
Figure 2-17. Sodium Adsorption Ratio (SAR) for the Rosebud Creek watershed. 29
Figure 2-18. Soil clay content for the Rosebud Creek watershed. 30
Figure 2-19. Land Ownership in the Rosebud Creek watershed. 34
Figure 3-1. Location of 1996 impaired streams in the Rosebud Creek watershed. 39
Figure 3-2. Rosebud Creek monitoring stations. 53
Figure 3-3. EC data for the lower Rosebud Creek (all stations). 57
Figure 3-4. EC data for the middle Rosebud Creek (all stations). 58
Figure 3-5. EC data for the upper Rosebud Creek (all stations). 58
Figure 3-6. Average monthly EC at three USGS stations (1980-2000). 59
Figure 3-7. Relationship between EC and flow at station 06296003. 59
Figure 3-8. Relationship between EC and flow at station 06295250. 60
Figure 3-9. Relationship between EC and TDS in the lower Rosebud Creek. 62
Figure 3-10. Relationship between EC and TDS in the middle Rosebud Creek. 63
Figure 3-11. Relationship between EC and TDS in the upper Rosebud Creek. 63
Figure 3-12. TDS data for Rosebud Creek. 64
Figure 3-13. Chloride data for Rosebud Creek. 66
Figure 3-14. SAR data for Rosebud Creek (all stations). 69
Figure 3-15. Calcium, magnesium, and sodium concentrations for lower Rosebud Creek (all stations). 69
Figure 3-16. TSS data for Rosebud Creek (all stations). 72
Figure 3-17. Relationship between TSS and flow at station 06296003. 72
Figure 3-18. TP data for Rosebud Creek (all stations). 76
Figure 3-19. TN data for Rosebud Creek (all stations). 76
Figure 3-20. NN data for Rosebud Creek (all stations). 77
Figure 3-21. Dissolved oxygen data for Rosebud Creek (all stations). 77
Figure 3-22. Sulfate data for lower Rosebud Creek (all stations). 79
Figure 3-23. Sulfate data for middle Rosebud Creek (all stations). 80
Figure 3-24. Sulfate data for upper Rosebud Creek (all stations). 80

Figure 4-1. 2003 main stem sampling sites for the Rosebud Creek watershed. 87
Figure E-1. Summary of salinity (EC) exceedances for Rosebud Creek (growing season). E-4
Figure E-2. Summary of salinity (EC) exceedances for Rosebud Creek (non-growing season). E-4
Figure E-3. Summary of SAR exceedances for Rosebud Creek (year-round).. E-6

ACRONYM LIST

ARM	Administrative Rules of Montana
BEHI	Bank erosion hazard index
BLM	Bureau of Land Management
CBM	Coal bed methane
CFS	Cubic feet per second
CV	Coefficient of variation
DO	Dissolved oxygen
EC	Electrical conductivity
EIS	Environmental Impact Statement
GAP	Gap analysis project
GIS	Geographic information system
MDEQ	Montana Department of Environmental Quality
MLRA	Major land resource area
MRLC	Multi-Resolution Land Characterization
NASS	National Agricultural Statistics Service
NCEPD	Northern Cheyenne Environmental Protection Department
NOAA	National Oceanic and Atmospheric Administration
NRCS	Natural Resources Conservation Service
NTU	Nephelometric turbidity units
NWIS	National Water Information System
SAR	Sodium adsorption ratio
SC	Specific conductance
SDDENR	South Dakota Department of Environment and Natural Resources
STATSGO	State Soil Geographic Database
TDS	Total dissolved solids
TMDL	Total maximum daily load
TN	Total nitrogen
TP	Total phosphorus
TPA	TMDL planning area
TR	Total Recoverable
TRWU	Tongue River Water Users
TSI	Trophic state index
TSS	Total suspended solids
T&Y	Tongue and Yellowstone Irrigation District
USDI	United States Department of Interior
USEPA	United State Environmental Protection Agency
USFS	United States Forest Service
USGS	United States Geological Survey
USLE	Universal Soil Loss Equation
WRCC	Western Regional Climate Center

1.0 INTRODUCTION

1.1 Background

Rosebud Creek encompasses approximately 1,304 square miles in the state Montana. The headwaters originate in the south-central Montana and flow to the northeast to the confluence with the Yellowstone River. Major tributaries include Greenleaf Creek, Lame Dear Creek, Muddy Creek, Cottonwood Creek, and West Rosebud Creek. Rosebud Creek has a total length of about 208 river miles flowing through Big Horn County and Rosebud County, Montana. It follows a winding course through a relatively narrow valley bounded by rolling benches. Rosebud Creek is one of several major tributaries to the Yellowstone River and is 2 percent of the total Yellowstone River drainage area.

The focus of this document is the Rosebud Creek watershed in State of Montana. This area is referred to as the Rosebud Creek Total Maximum Daily Load (TMDL) Planning Area (TPA). Although the focus of this document is on the main stem of Rosebud Creek, the relevant physical, chemical, and biological characteristics within the entire watershed, including all tributaries, are considered herein.

Stream segments designated as "water quality impaired" or "threatened" are listed on Montana's 303(d) list and require the development of TMDLs. Within the Rosebud Creek TPA, Rosebud Creek was the only waterbody listed as impaired on the 1996 303(d) list (see Section 3.0 for details regarding the 303(d) list status of this waterbody). On September 21, 2000, the United States District Court of Montana ordered the U.S. Environmental Protection Agency (USEPA) to work with the Montana Department of Environmental Quality (MDEQ) to develop and adopt a schedule to develop all necessary TMDLs for waters on Montana's 1996 Section 303(d) list by May 5, 2007. See, *Friends of the Wild Swan, Inc. et al., vs. U.S. Environmental Protection Agency*, CV 97-35-M-DWM. In accordance with the original schedule, all necessary TMDLs for the Rosebud Creek TPA were to be completed by December 31, 2006. However, the MDEQ has decided to accelerate the schedule for this TPA to facilitate coordination between the TMDL program and ongoing efforts relative to development of coal-bed methane (CBM). As will be described below in Section 1.3, interim, framework TMDLs may be completed as early as June/July 2003. However, the final target date for completion of all necessary TMDLs for this TPA is December 31, 2003.

The TMDL process identifies the maximum load of a pollutant (e.g., sediment, nutrient, metal) a waterbody is able to assimilate and fully support its designated uses, allocates portions of the maximum load to all sources, identifies the necessary controls that may be implemented voluntarily or through regulatory means, and describes a monitoring plan and associated corrective feedback loop to insure that uses are fully supported. A TMDL can also be viewed as the total amount of pollutant that a waterbody may receive from all sources without exceeding water quality standards. Montana's approach is to include TMDLs as a part of a comprehensive water quality restoration plan containing seven principal components:

COAL-BED METHANE (CBM)

Coal-bed methane production has rapidly increased throughout the United States in the past several years. USGS estimates that methane gas extracted from coal seams now accounts for 7.5 percent of the natural gas production in the U.S. (USGS, 2000). Extracting methane gas from coal seams is a relatively new and simple process. Large quantities of methane gas are found in coal beds. The methane is trapped in the coal beds because of pressure and the coal's high internal surface area. During CBM extraction, water is pumped out of the coal bed to reduce the pressure, thereby allowing methane to escape. The methane is collected and the water is disposed of to either the surface or subsurface.

The Montana Bureau of Land Management (BLM) estimated that 1,272 square miles (98 percent) of land in the Rosebud Creek watershed in Montana has the potential to produce CBM (USDI, 2001). It is estimated that the potential maximum number of wells in this area is 3,669 wells. Assuming that the maximum number of wells are installed, and they operate for 20 years, the BLM estimated that as much as 7.6 billion gallons of water would be discharged into the Rosebud Creek watershed over the life of the wells. This potentially enormous volume of water, as well as the constituents in the water, could have adverse affects on water resources in the Rosebud Creek watershed.

1. Watershed characterization (e.g., hydrology, climate, vegetation, land use, ownership)
2. Description of impairments and applicable water quality standards
3. Pollutant source assessment and estimate of existing pollutant loads
4. Water quality goals (i.e., water quality targets and TMDLs)
5. Allocation
6. Restoration strategy
7. Monitoring Strategy

MDEQ has chosen a phased approach for the establishment of TMDLs in the Rosebud Creek TPA. The phased approach has been selected to accommodate the following issues:

1. The intent of the TMDL program is to attain and maintain water quality standards. In fact, water quality standards are the basis from which TMDL's are established and the TMDL targets are derived. The Montana Board of Environmental Review (the Board) is considering adoption of numeric water quality standards for sodicity (as SAR) and salinity (as EC) for the Tongue River, Powder River, Little Powder River and Rosebud Creek watersheds to address current and projected development of coal bed methane (CBM) within these watersheds. As currently planned, the Board is not scheduled to make their final decision regarding adoption of numeric water quality standards until March 28, 2003, at the earliest. If the Board adopts numeric water quality standards, they will form the basis for establishment of TMDL's in the Rosebud Creek TPA. If the Board does not adopt them, the existing narrative standards will have to be interpreted to derive TMDL's and TMDL numeric targets. Given the above described schedule and the interrelationship between the State's Standards and TMDL Programs, it is not possible to proceed with a final TMDL until final decisions have been made regarding the adoption of numeric criteria.

2. Typically, in the TMDL process, when numeric water quality standards are available for a pollutant of concern, they are used to make water quality impairment determinations and form the basis for numeric water quality targets. For example, if the numeric water quality standard is exceeded a certain percent of the time, the water body is considered impaired.

   DEQ has proposed the establishment of numeric water quality standards for electrical conductivity (EC) and sodium adsorption ratio (SAR) specific to the Tongue River, Powder River, Little Powder River, Rosebud Creek and their tributaries. While DEQ's proposal may result in establishment of numeric water quality standards (e.g., 1900 µS/cm EC in the Little Powder River), the provisions of 75-5-306 MCA provide that "*It is not necessary that wastes be treated to a purer condition than the natural condition of the receiving stream so long as the minimum treatment requirements established under this chapter are met*".
   Natural refers to "*conditions or materials present in the runoff or percolation over which man has no control or from developed land where all reasonable land, soil and water conservation practices have been employed*".

   The provisions of 75-5-306 MCA make it impossible to use DEQ's numeric criteria for making a Clean Water Act 303(d) water quality impairment determination without first defining the natural condition of the receiving stream.

3. While in most cases sufficient data is available to describe ambient water quality conditions, there is currently insufficient site-specific monitoring data to define the natural condition (i.e., to what extent the existing water quality is a function of natural versus human caused activities) of the

waters within the Rosebud Creek TPA and/or to derive appropriate TMDL targets that are both protective of beneficial uses and reflect the water quality potential of the subject waterbodies.

4. Insufficient site specific data exists to determine water quality impairment status and/or establish appropriate TMDL targets in Rosebud Creek for most parameters.

Each of the above issue necessitates a phased TMDL approach where additional time is provided to collect supplemental water quality data and the Board is provided time to make final decisions regarding the adoption of numeric water quality criteria.

1.2 Document Purpose and Content

This document presents the results of the first phase of TMDL development for the Rosebud Creek TPA. The purpose of this document is to provide a summary and status report of the TMDL-related work that has been performed to date, completes the first component of the TMDL process as defined above (i.e., Watershed Characterization), and preliminarily completes the second component of the process (i.e., Water Quality Impairment Status). This is a status report and comments from all interested parties are welcomed. Although MDEQ will not be preparing a revised version of this status report, all data and comments will be considered during the preparation of the final TMDLs.

This phase began almost two years ago when MDEQ began working with the Carter, Custer, Rosebud, Powder, Bighorn, and Prairie County Conservation Districts, with USEPA funding, for the collection of water quality data in waterbodies within the TPA. The work has been conducted under the direction of MDEQ with technical assistance from USEPA and contractor support from Tetra Tech, Inc. The intent of Phase I is to develop a thorough understanding of the existing environment as it relates to water quality and to compile and evaluate all available water quality data to describe ambient water quality conditions. The physical, chemical, and biological characteristics of the environment in which the subject waterbodies exist are described in Section 2 – Watershed Characterization. A summary and evaluation of all available water quality information is presented in Section 3 – Water Quality Impairment Status. Section 3 also discusses identified data gaps. A monitoring plan to fill the identified data gaps is presented in Section 4 – Monitoring Strategy.

1.3 Future Phases

Phase I will provide the foundation upon which to make water quality impairment determinations and establish all necessary TMDLs for the Rosebud Creek TPA. As such, this Phase I report is a status report and a subset of the final TMDL report. All available information at the time of this report were used in the analyses and conclusions. Additional data and comments applicable to all phases of the TMDL process will continue to be acquired and used. Subsequent phases of the TMDL process will build upon the information presented in this report to establish appropriate targets, and source allocations. Potentially, two additional phases will be initiated. These are described in the following paragraphs.

1.3.1 Phase II – Interim Framework TMDL's

The previously mentioned court order not only stipulated that USEPA and the state work together to develop and implement a schedule for completing all necessary TMDLs, but went on to state that "*Until all necessary TMDLs are established for a particular water quality limited segment, the EPA shall not issue any new permits or increase permitted discharges for any permittee under the National Pollutant Discharge Elimination System permitting program or under the Montana Pollutant Discharge Elimination System*." In other words, this stipulates that the state or USEPA can permit no new or increased discharges until all necessary TMDLs are completed.

Phase II would be optionally implemented at MDEQ's discretion in an attempt to avoid permitting delays that might be forced as a result of this court-ordered stipulation. Phase II could be completed within approximately two to three months of a decision by the Board to adopt, or not adopt, numeric water quality criteria (e.g., a draft Phase II TMDL document completed in June/July 2003 assuming the Board makes a final decision March 28, 2003).

Phase II would use all currently available information to develop framework TMDLs for CBM-related parameters and would establish interim numeric water quality targets, TMDLs, and allocations that would be "in effect" until Phase III is completed in December 2003. The Phase II process would facilitate immediate protection of beneficial uses using the best available data and may allow for some discharges of CBM-related parameters in some waters while additional data are collected, and analyses are conducted in Phase III to refine final targets and TMDLs.

MDEQ's decision to proceed with Phase II will be based on: (1) permit applications for proposed CBM discharges, and (2) the period of time over which the Phase II interim, framework TMDL would be in effect. If factors other than the TMDL process continue to drive the CBM development issue (e.g., the Environmental Impact Statement or delays in the decision to adopt numeric water quality criteria) there may be no need to proceed with Phase II given that the Phase III process is scheduled for completion by December 31, 2003. On the other hand, if it appears that the court-ordered stipulation would drive the CBM development issue, it may be prudent for the state to proceed with Phase II to avoid permit delays.

1.3.2 Phase III – Final TMDL's

The need for additional data collection is described above in Section 1.1. Phase III has been proposed to facilitate the collection of additional data and to provide additional time to apply the appropriate analytical tools to ultimately complete all seven components of the TMDL process based on the best available, up-to-date water quality data.

Phase III is intended to result in the establishment of all necessary, final TMDLs for all pollutant/ waterbody combinations appearing on the 1996 303(d) list. Phase III will fill data gaps identified in Phase I through implementation of a rigorous monitoring program, establish final numeric targets based on the newly acquired data and application of appropriate analytical tools (e.g., models), apply the final targets to develop final TMDLs and allocations for CBM-related parameters, and to establish all necessary TMDLs for all of the non-CBM related pollutants appearing on the 1996 303(d) list. The target completion date for Phase III is December 31, 2003, assuming that favorable/representative weather conditions exist in the spring and summer of 2003 for the collection of the necessary supplemental monitoring data.

2.0 WATERSHED CHARACTERIZATION

The intent of this section of the document is to put the subject water bodies into context with the watershed in which they occur. This section provides the reader with a general understanding of the environmental characteristics of the watershed that may have relevance to the 303(d) listed water quality impairments. This section also provides some detail regarding those characteristics of the watershed that may play a significant role in driving pollutant loading (e.g., geographical distribution of soil types, vegetative cover, land use, etc.). The information provided in this section is provided for context. A more detailed consideration of some of this information, at a finer scale, will likely be included in the final TMDL document.

2.1 Physical Characteristics

2.1.1 Location

The Rosebud Creek watershed, located entirely in Montana, encompasses approximately 1,304 square miles. Bounded by the Tongue River watershed on the east, the headwaters originate in southeastern Montana and the creek flows generally to the northeast toward its confluence with the Yellowstone River as shown in Figure 2-1. Major tributaries to Rosebud Creek include the West Fork Rosebud Creek, South Fork Rosebud Creek, North Fork Rosebud Creek, Greenleaf Creek, Lame Deer Creek, and Muddy Creek. The watershed is located entirely in one USGS 8-digit hydrologic cataloging unit, HUC 10100003, and includes portions of Big Horn and Rosebud counties.

Rosebud Creek near the Northern Cheyenne Reservation
(Photograph by Tetra Tech, Inc.)

2.1.2 Climate

Climate in the Rosebud Creek watershed is characterized by colder and wetter conditions in the headwaters and temperate to semi-arid conditions in lower elevations. Annual precipitation and temperature are largely governed by elevation in the watershed. The continental location of the watershed results in a climate that is marked by seasonal variations and extremes in precipitation and temperature. Average monthly precipitation is greatest from April through June while significant snowfall begins in October and continues through May. Temperatures reach their maximum and minimum values in July and January, respectively.

The National Oceanic and Atmospheric Administration (NOAA) collects data from four climate stations located within the Rosebud Creek watershed, as shown in Figure 2-2 and listed in Table 2-1. A graphical summary of the average climatic characteristics at a station is called a climagraph. Figure 2-3 illustrates annual average precipitation and temperature for the Busby Montanan station (NOOA Cooperative station number 487376). This station typifies climates in the upper reaches of Rosebud Creek, and shows that much of the snowfall occurs from October through April, while most of the rainfall occurs from April through July (WRCC, 2002). Total annual average precipitation and total annual average snowfall at this station are 14.2 inches and 44.0 inches, respectively. Average monthly temperatures range from a maximum of 69.6 °F in July to a minimum of 18.0 °F in January. In addition, historical climate data for the Kirby station (NOOA Cooperative station number 244701) depicts conditions in the Rosebud Creek headwaters. Average annual precipitation and snowfall measurements for this station are 19.2 inches and 80.6 inches, respectively.

As in the headwaters, average monthly precipitation throughout the lower portion of the watershed is greatest from April through July, and maximum temperatures occur in July, while minimum values occur in January. Figure 2-4 displays a climagraph for the Colstrip station, Montana (NOOA Cooperative station number 241905). This station is located in the lower third of the watershed, and is typical of lower elevation plains regions in the watershed. The climagraph shows that average monthly precipitation is greatest from April through September, with May and June being the wettest months. Total annual average precipitation is 14.73 inches, while total annual average snowfall is 37.0 inches (WRCC, 2002). Average monthly temperatures range from a maximum of 71.3 °F in July to a minimum of 21.9 °F in January.

Another important climatic factor for the entire watershed, particularly from a water management perspective, is evaporation rate, which is largely dependent on air temperature, wind speed, and elevation (Reider, 1990). Evaporation is a major water loss from watersheds, especially in arid and semi-arid climates. Total annual evaporation in the Rosebud Creek watershed is approximately 35 inches. In lower elevation areas, evaporation exceeds precipitation on an annual average basis (WRCC, 2002).

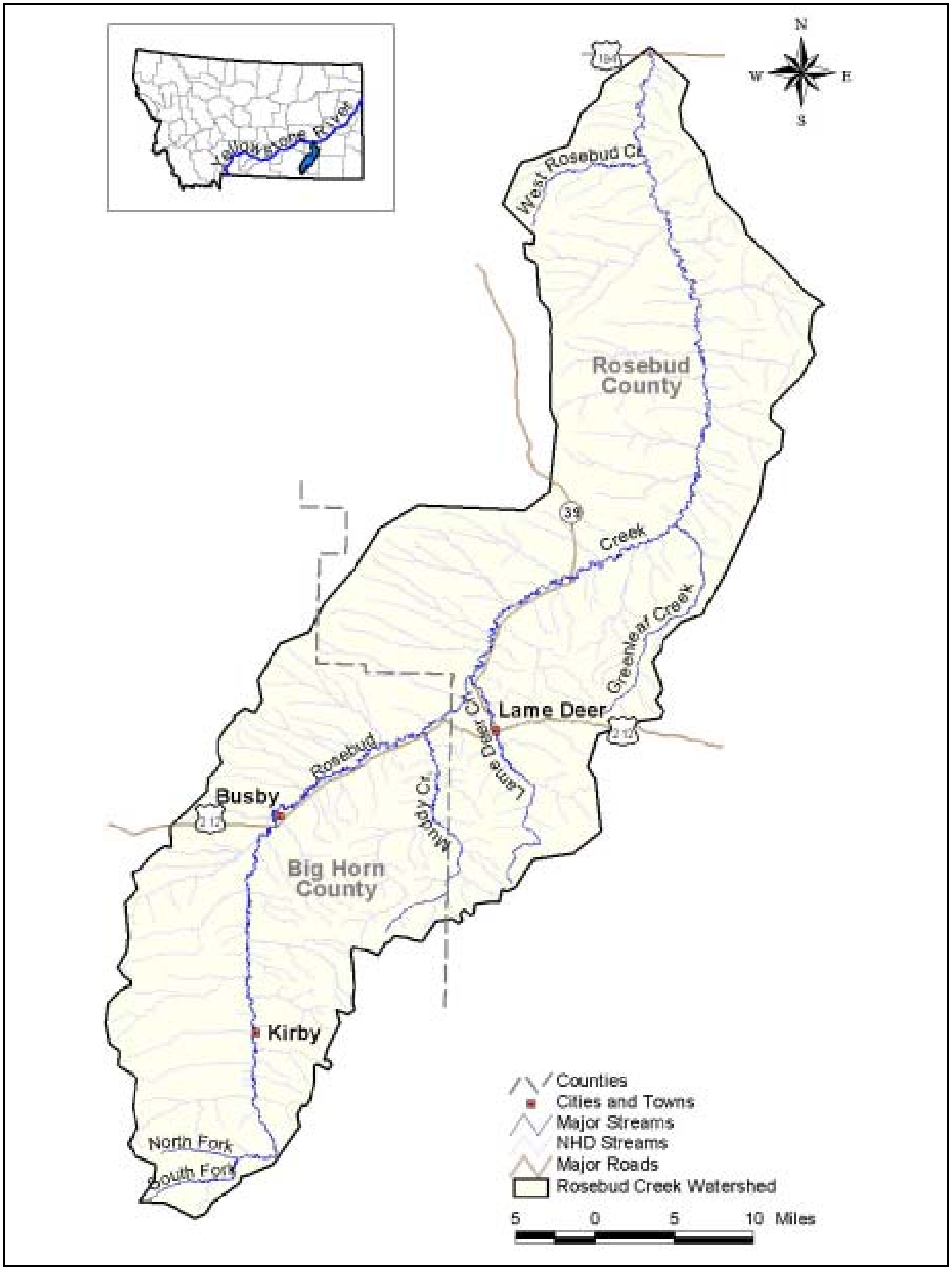

Figure 2-1. Location of the Rosebud Creek watershed.

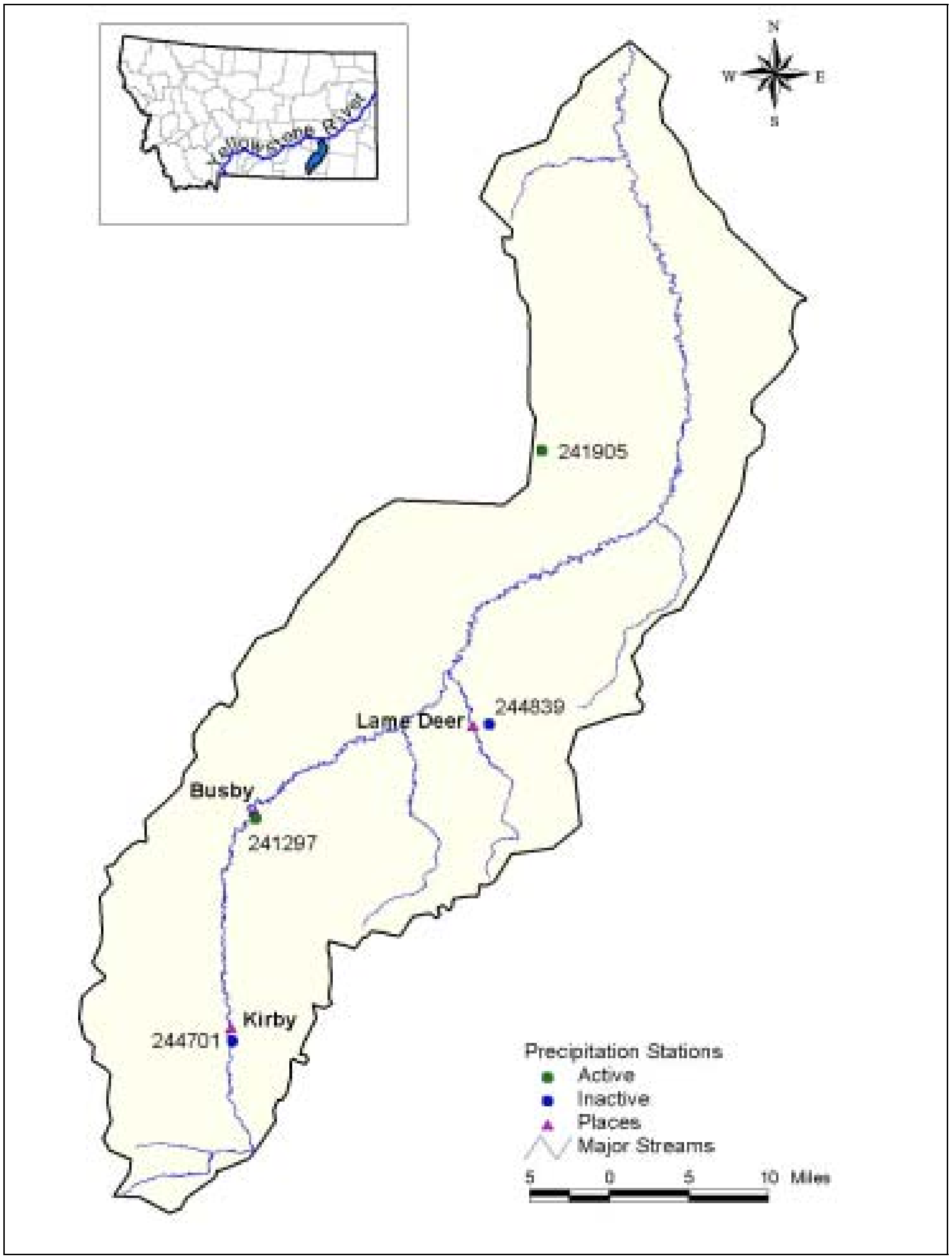

Figure 2-2. Distribution of NOAA climate stations in the Rosebud Creek watershed.

Table 2-1. NOAA climate stations located in the Rosebud Creek watershed.

Station Name	Coop-ID	Period of Record		Elevation (ft.)
Busby	241297	7/1/48	to present	3,440
Colstrip	241905	7/1/48	to present	3,221
Lame Deer	244839	7/1/48	to 3/3/00	3,390
Kirby 1 S	244701	11/1/59	to 12/2/75	3,953

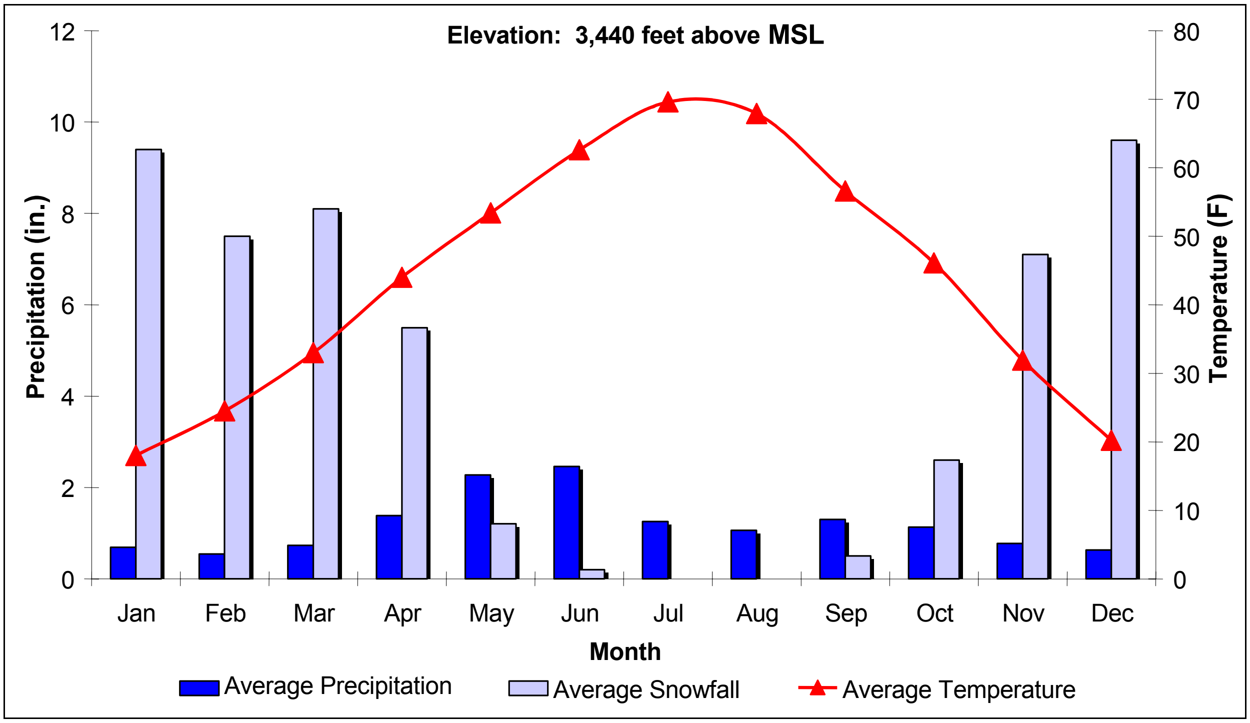

Figure 2-3. Climagraph for Busby, MT, station 241297.

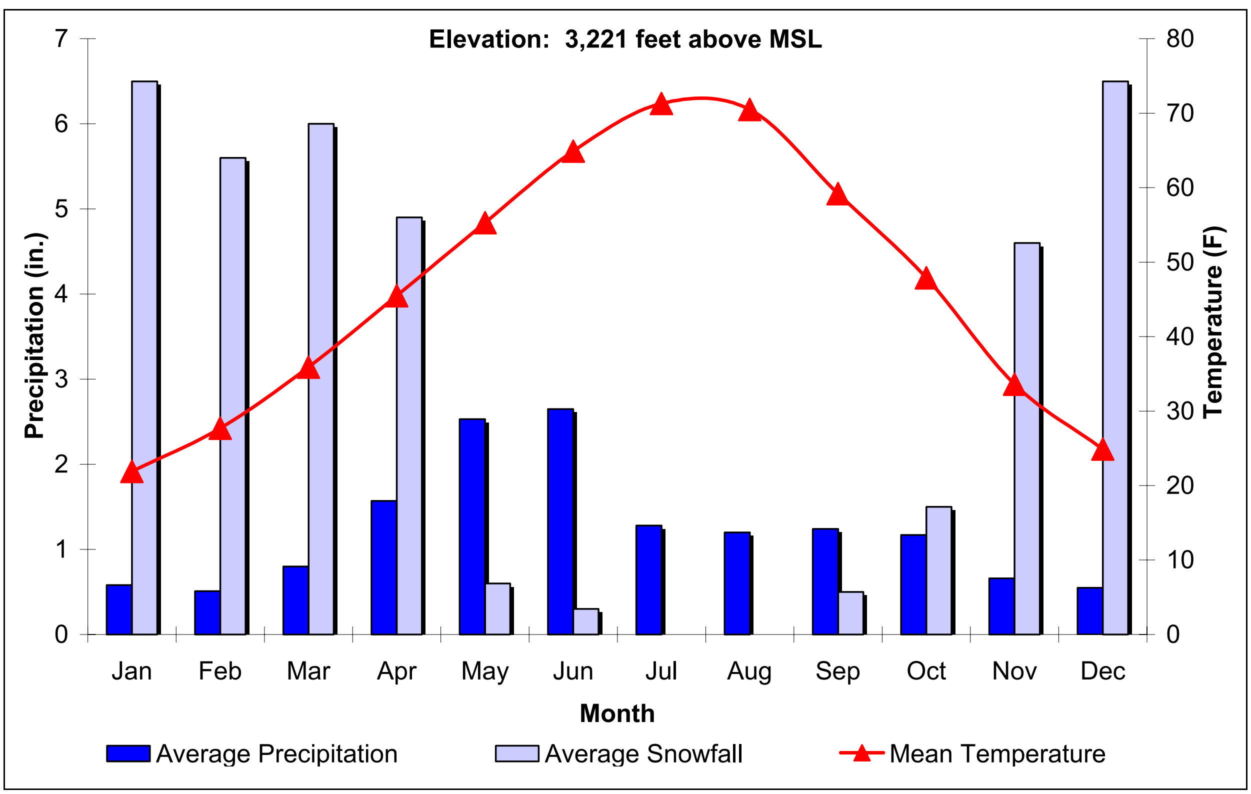

Figure 2-4. Climagraph for Colstrip, MT, station 241905.

2.1.3 Hydrology

2.1.3.1 Rosebud Creek Flow Data - Main Stem

The U.S. Geologic Survey (USGS) National Water Information System (NWIS) online database lists seven flow gages with current and historic flow data in the Rosebud Creek watershed. Three stations on the main stem of Rosebud Creek were analyzed to obtain a general understanding of flow from the headwaters to the mouth at the Yellowstone River. These stations were – Rosebud Creek at Reservation Boundary near Kirby, MT; Rosebud Creek near Colstrip, MT; and Rosebud Creek at mouth near Rosebud, MT. These stations are shown in Figure 2-5 and described in Table 2-2.

Figure 2-5. Location of selected USGS stations in the Rosebud Creek watershed.

The flow patterns at the three main stem stations are very similar. Figure 2-6 shows that there is an increase in flow in February and March that is attributable to snowmelt at lower elevations. Flows then decrease in April and increase again in May due to snowmelt at higher elevations and precipitation. By the end of July, evaporation, reduced precipitation, and withdrawals cause the river to flow at baseflow. Flow slightly increases from upstream to downstream and the most pronounced changes in flow occur during the rainfall and snowmelt season. The high variability in daily flows, exemplified by stations 06295250 and 06296003, result from flows sustained by intense rainstorms and snowmelt (USGS, 1999). Most of Rosebud Creek and many of its tributaries flowing from the plains regions are ephemeral. However, streams flowing from the mountainous areas are often perennial and sustained by precipitation and snowmelt.

Table 2-2. Selected USGS stream gages for Rosebud Creek.

Station ID	Gage Name	Drainage Area (mi^2)	Period of Record	
			Start Date[a]	End Date[b]
06295113	Rosebud Creek at Reservation Boundary near Kirby, MT	123	1979	Current
06295250	Rosebud Creek near Colstrip, MT	799	1974	Current
06296003	Rosebud Creek at mouth near Rosebud, MT	1,302	1974	Current

[a]The first year in which continuous flow data are available.
[b]The last year in which continuous flow data are available.

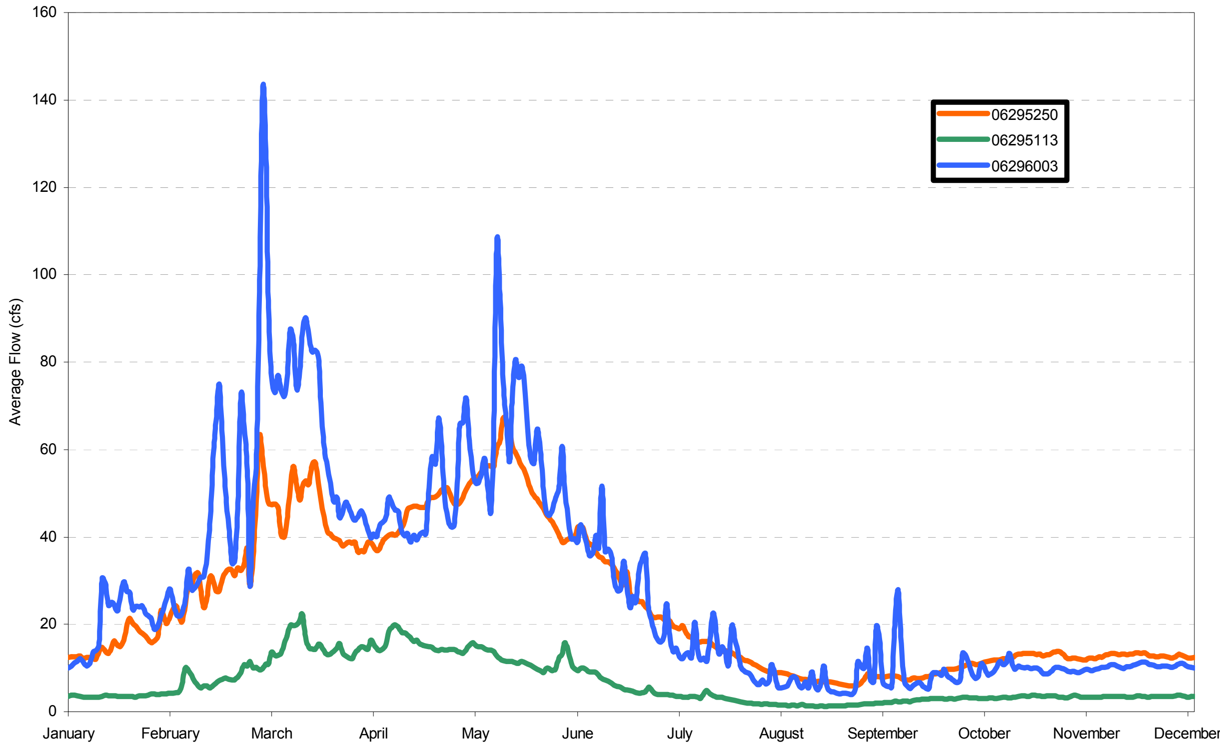

Figure 2-6. Average daily flows at three USGS gages on the main stem of Rosebud Creek (entire period of record is shown).

2.1.3.3 Stream Types

The National Hydrography Data (NHD) provided by U.S. Environmental Protection Agency (USEPA) and USGS identified the major stream types in the Rosebud Creek watershed. Most of the streams in the Rosebud Creek watershed were classified as intermittent streams (Table 2-3). Intermittent streams have flow only for short periods during the course of a year, and flow events are usually initiated by rainfall. Perennial stream flow was classified only in the headwaters of the watershed including Rosebud Creek and most of its tributaries (Figure 2-7). Mountain streams of varying sizes have perennial flow due to snowmelt and precipitation, while streams at lower elevations are generally intermittent and flow after local rainstorms. Most of the canals, ditches, connectors, and artificial paths are located in the headwaters of Rosebud Creek and Muddy Creek as well as near the mouth of Rosebud Creek. This is most likely to take advantage of snowmelt runoff and high flows for irrigated crop production.

Table 2-3. Summary of stream type in the Rosebud Creek watershed.

Stream Type	Stream Length (m)	Percent
Intermittent	1,878,773	79.39
Perennial	474,898	20.07
Artificial Path	6,797	0.29
Connector	3,508	0.15
Canal/Ditch	2,432	0.10
Total	2,366,408	100.00

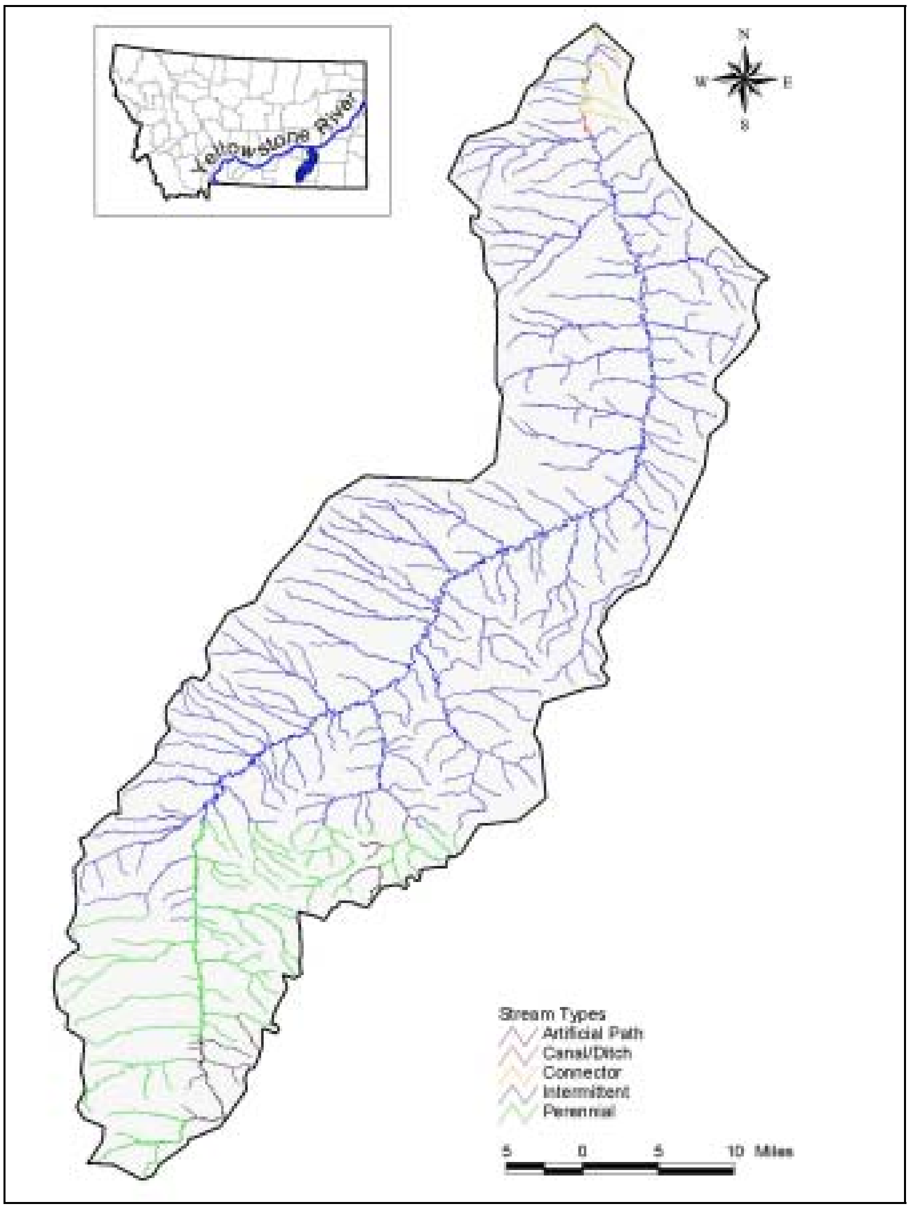

Figure 2-7. Stream types in the Rosebud Creek watershed.

2.1.3.4 Irrigation Practices

Assessment of water right information provides a means of determining appropriation and beneficial uses of water in the Rosebud Creek watershed. Water right information acquired from the Montana Department of Natural Resources and Conservation (DNRC) shows that currently there are 100,797 acre-feet of water per year in the Rosebud Creek watershed allocated to surface water rights, and 2,326 acre-feet of water per year allocated to groundwater rights. This is the maximum amount of water that can potentially be used throughout the watershed per year, and it does not necessarily reflect water use. Water is primarily used for irrigation, municipal, stock watering, and domestic uses. Most of the water (74 percent) is used for irrigation (Table 2-4).

Table 2-4. Surface water uses designated by water rights.

Water Purpose	Volume (acre-feet/year)	Percentage
Irrigation	25,606	74.19%
Stock water	8,194	23.74%
Wildlife/waterfowl	257	0.74%
Wildlife	252	0.73%
Other	203	0.59%
Total	**34,512**	**100.00%**

2.1.4 Groundwater

A shallow aquifer system underlies the Rosebud Creek watershed and is composed of five hydrogeologic units located above a relatively regionally persistent and highly impermeable lithologic unit called the Upper Cretaceous Bearpaw Shale (Lewis and Hotchkiss, 1981). The uppermost hydrogeologic unit in the shallow aquifer system is the Wasatch-Tongue River aquifer, an extensive aquifer that is up to 1,190 meters thick and is exposed at the land surface throughout most of the watershed (Lewis and Hotchkiss, 1981).

Underlying the Wasatch-Tongue aquifer and extending over much of the watershed is the Lebo confining layer. This confining layer is up to 920 meters thick and generally correlates with the Lebo Shale Member of the Fort Union Formation (Lewis and Hotchkiss, 1981). Underlying the Lebo confining layer, except near outcrop areas, is the Tullock aquifer. The Tullock aquifer is up to 600 meters thick and is considered an aquifer in most of the watershed (Lewis and Hotchkiss, 1981). The Tullock aquifer is confined by the Upper Hell Creek layer, which underlies much of the watershed. Groundwater may be a potential source of pollutants in the Rosebud Creek watershed, and more information regarding the impact of groundwater on surface water beneficial uses will be presented in the Source Assessment section of the TMDL.

2.1.5 Topography

Figures 2-8 display the general topography within the Rosebud Creek watershed, and a shaded relief map of the watershed is presented in Figure 2-9. As seen in Figure 2-8, elevations generally range from around 5,128 feet above mean sea level in the southwestern portion of the watershed to 2,477 feet in the northern portion of the watershed.

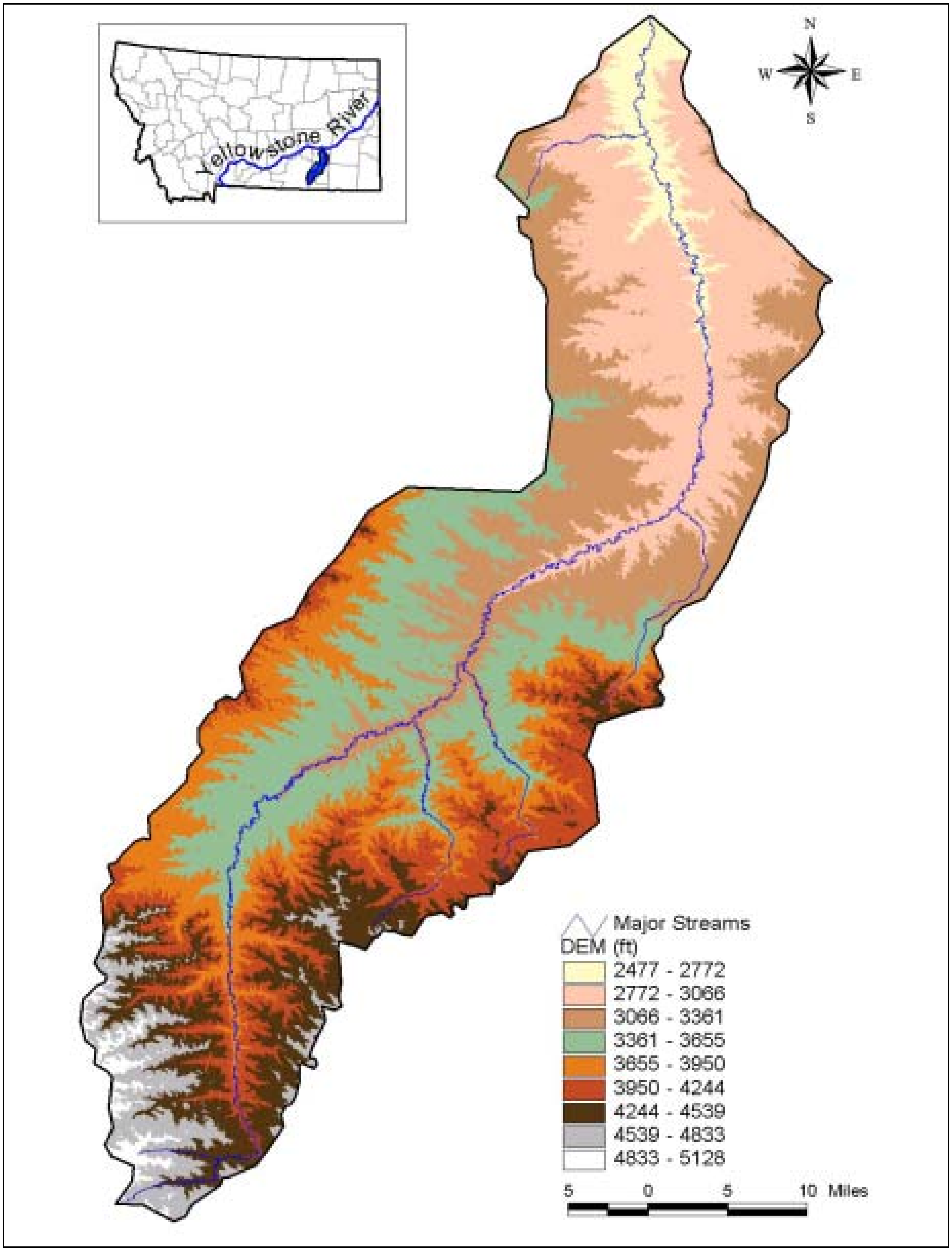

Figure 2-8. Elevation in the Rosebud Creek watershed.

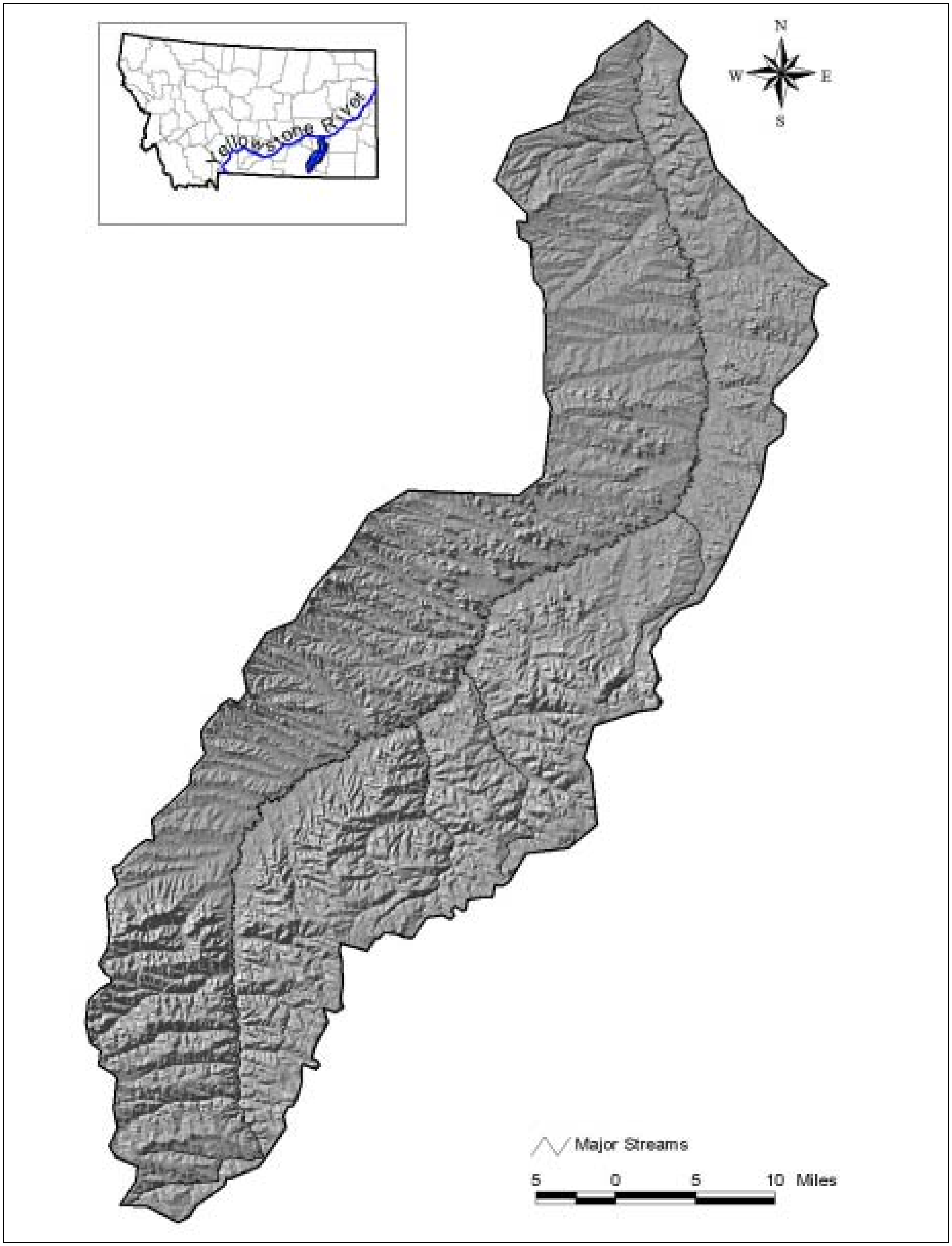

Figure 2-9. Shaded relief of the Rosebud Creek watershed.

2.1.6 Major Land Resource Areas

The USDA has determined major land resource areas (MLRAs) within the U.S. (USDA, 1965). The MLRAs are large area land resource units geographically associated according to the dominant physical characteristics of topography, climate, hydrology, soils, land use, and potential natural vegetation. MLRAs have been used in statewide agricultural planning and have value in interstate, regional, and national planning. The entire Rosebud Creek watershed is located in MLRA 58A, Northern Rolling Plains, Northern Part. A complete description of this MLRA is given in Appendix A.

2.1.7 Land Use and Land Cover

General land use and land cover data for the Rosebud Creek watershed were extracted from the Multi-Resolution Land Characterization (MRLC) database (MRLC, 1992) and are shown in Figure 2-10. This database was derived from satellite imagery taken during the early 1990s and is the most current detailed land use data known to be available. Each 100-foot by 100-foot pixel contained within the satellite image is classified according to its reflective characteristics. A complete listing and definition of the MRLC land cover categories is given in Appendix B. Table 2-5 summarizes land cover in the Rosebud Creek watershed and shows that grassland is the dominant land cover, comprising approximately 65.45 percent of the total land cover. Evergreen forest and shrublands comprise 20.43 percent and 7.11 percent, respectively. Other important cover types include small grains (2.39 %), deciduous forest (1.62%), and fallow land (1.28 %). All other land cover types account for less than two percent of the total watershed area.

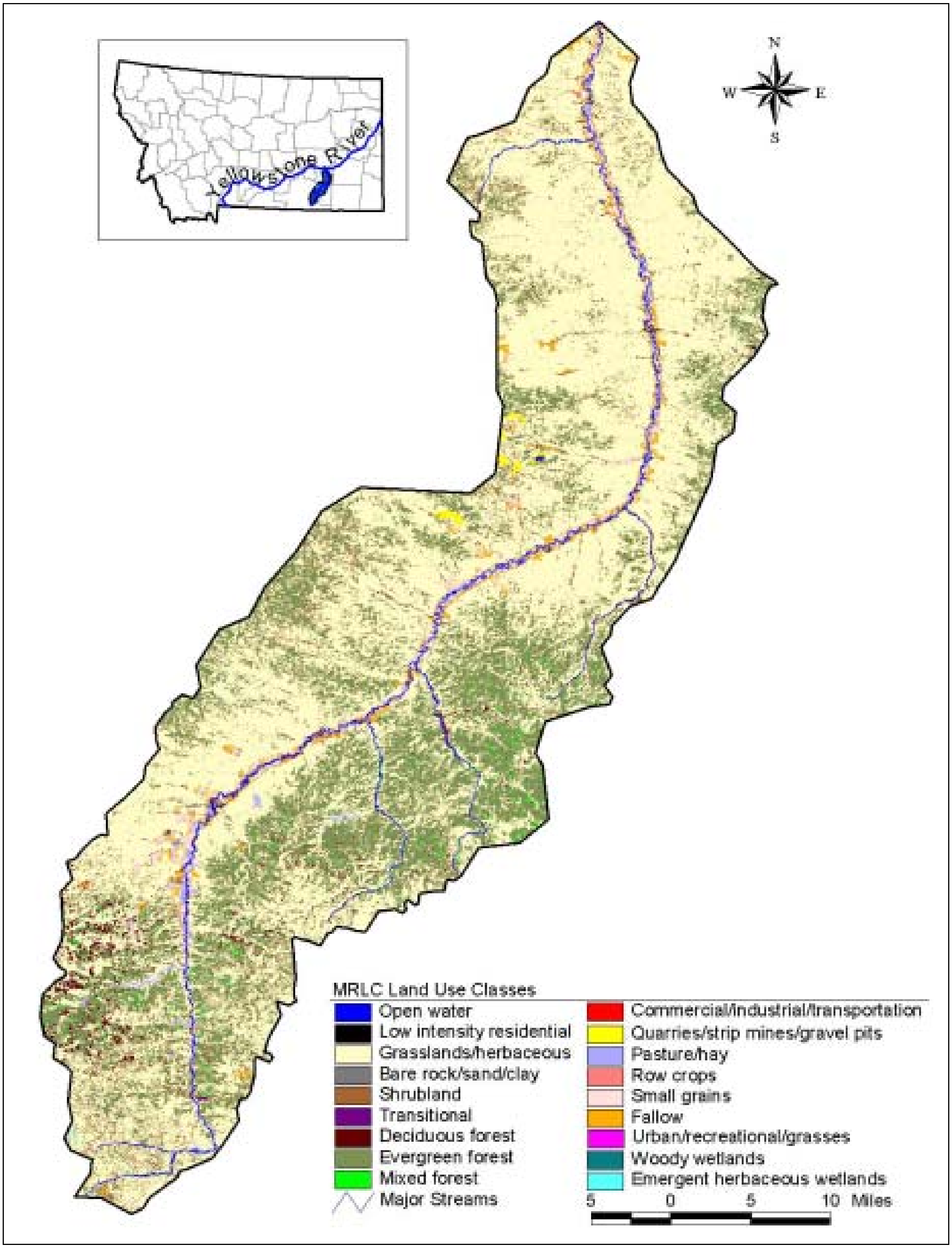

Figure 2-10. Land use and land cover in the Rosebud Creek watershed.

Table 2-5. Land use and land cover in the Rosebud Creek watershed.

Land Use/Land Cover	Area		Percent of Watershed
	Acres	Square Miles	
Grasslands/herbaceous	546,430	853.8	65.45
Evergreen forest	170,530	266.5	20.43
Shrubland	59,357	92.7	7.11
Small grains	19,956	31.2	2.39
Deciduous forest	13,487	21.1	1.62
Fallow	10,660	16.7	1.28
Pasture/hay	6,006	9.4	0.72
Mixed forest	4,125	6.4	0.49
Quarries/strip mines/gravel pits	1,481	2.3	0.18
High intensity residential	764	1.2	0.09
Row crops	551	0.9	0.07
Emergent herbaceous wetlands	402	0.6	0.05
Open water	322	0.5	0.04
Bare rocks/sand/clay	373	0.6	0.04
Low intensity residential	150	0.2	0.02
Woody wetlands	172	0.3	0.02
Transitional	79	0.1	0.01
Urban/recreational grasses	0	0.0	0.00
Total	834,846	1304.5	100.00

2.1.8 Vegetative Cover

Vegetative data were gathered from Gap Analysis Project completed for Montana. The Gap Analysis is a nation-wide program conducted under the guidance of the USGS for the purpose of assessing the extent of conservation of native plant and animal species. Since an important part of the analyses is the identification of habitat, detailed vegetative spatial data are usually available for states that have completed their analyses. Like the MRLC data, the spatial database for Montana was derived from satellite imagery taken during the early 1990s. However, the vegetative classification is much more detailed than that of the MRLC; the GAP data includes vegetative species such as ponderosa pine, rather than general land cover classes like evergreen forest. Vegetative cover provided by GAP data for the Rosebud Creek watershed is shown in Figure 2-11 and summarized in Table 2-6.

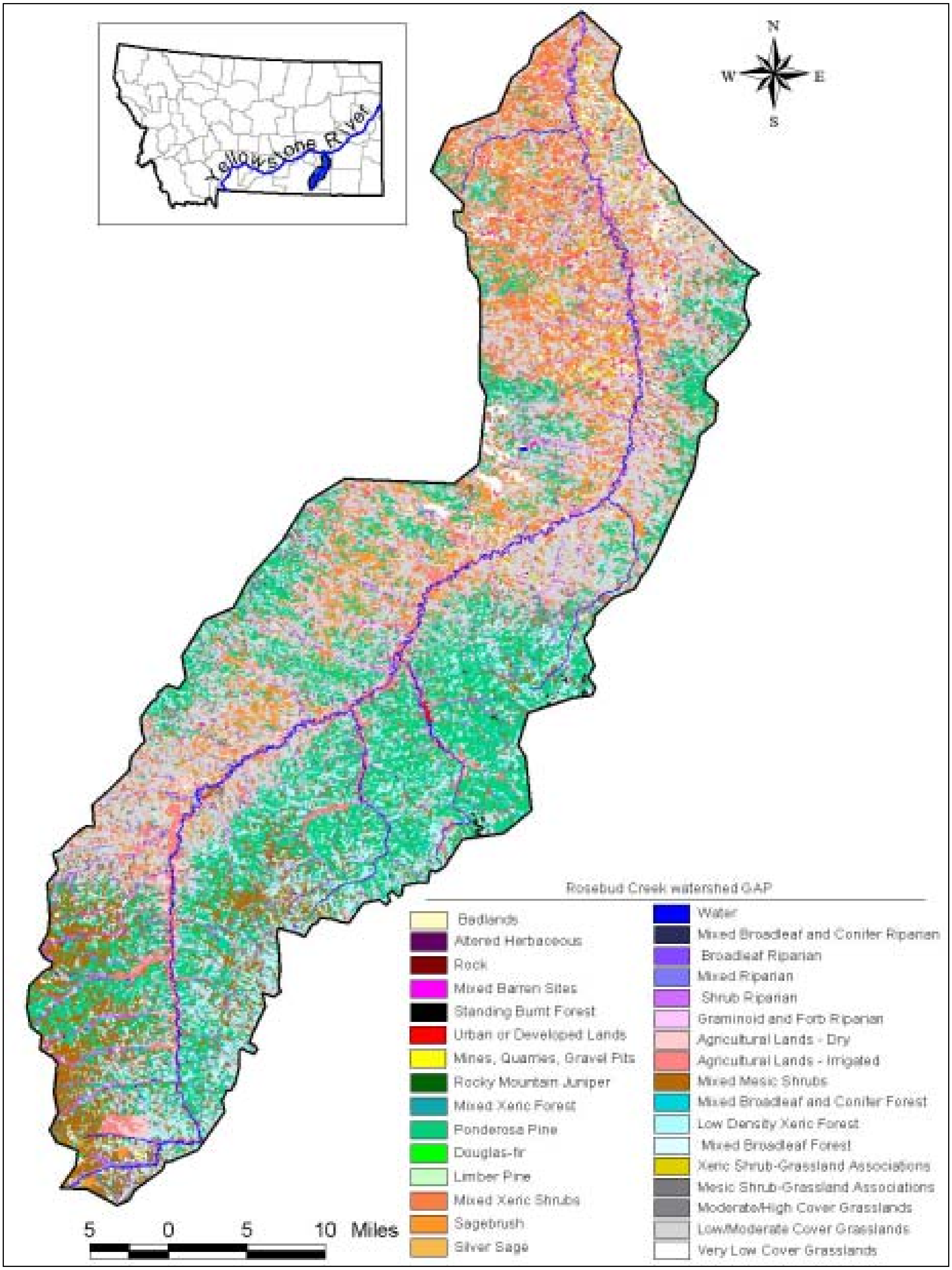

Figure 2-11. Vegetative cover in the Rosebud Creek watershed.

Table 2-6. Vegetative cover according to the GAP analysis for the Rosebud Creek watershed.

Vegetative Cover	Area		Percent of Watershed
	Acres	Square Miles	
Low/Moderate Cover Grasslands	233,767	365.3	28.00
Ponderosa Pine	166,268	259.8	19.92
Mixed Xeric Shrubs	78,744	123.0	9.43
Low Density Xeric Forest	74,586	116.5	8.93
Mixed Mesic Shrubs	55,962	87.4	6.70
Sagebrush	41,399	64.7	4.96
Moderate/High Cover Grasslands	31,410	49.1	3.76
Agricultural Lands - Irrigated	24,805	38.8	2.97
Graminoid and Forb Riparian[1]	20,830	32.5	2.50
Badlands	19,543	30.5	2.34
Shrub Riparian	18,410	28.8	2.21
Mesic Shrub-Grassland Associations	14,681	22.9	1.76
Agricultural Lands - Dry	8,869	13.9	1.06
Mixed Broadleaf and Conifer Forest	7,175	11.2	0.86
Mixed Broadleaf Forest	6,751	10.5	0.81
Mixed Barren Sites	5,886	9.2	0.71
Very Low Cover Grasslands	5,278	8.2	0.63
Xeric Shrub-Grassland Associations	5,086	7.9	0.61
Broadleaf Riparian	4,944	7.7	0.59
Mixed Riparian	3,703	5.8	0.44
Mines, Quarries, Gravel Pits	3,222	5.0	0.39
Mixed Broadleaf and Conifer Riparian	1,155	1.8	0.14
Standing Burnt Forest	630	1.0	0.08
Water	610	1.0	0.07
Urban or Developed Lands	330	0.5	0.04
Rock	180	0.3	0.02
Altered Herbaceous	130	0.2	0.02
Douglas-fir	118	0.2	0.01
Limber Pine	108	0.2	0.01
Mixed Xeric Forest	82	0.1	0.01
Rocky Mountain Juniper	76	0.1	0.01
Silver Sage	38	0.1	<0.00
Total	834,777	1,304.4	100.00

[1] Graminoid and forbs refer to grasses and grass-like plants, including sedges and rushes and broad-leaved herbaceous plants, respectively.

Inspection of Figure 2-11 and Table 2-6 shows that low to moderate cover grasslands and Ponderosa pine dominant vegetative cover and occupy 28.00 percent and 19.92 percent of the watershed, respectively. Mixed xeric shrubs, distributed throughout the lower and middle portions of the watershed, account for 9.43 percent of total watershed area, whereas, low-density xeric forests, evenly distributed throughout the watershed, contribute to 8.93 percent of vegetative cover. Mixed mesic shrubs account for 6.70 percent of vegetation in the watershed and are located in higher elevation headwaters where significant precipitation occurs. In addition, sagebrush, moderate to high cover grasslands, and irrigated agricultural lands comprise 4.96 percent, 3.76 percent, and 2.97 percent of the total vegetative cover, respectively.

2.1.9 Soils

Soils data and GIS coverages from the Natural Resources Conservation Service (NRCS) were used to characterize soils in the Rosebud Creek watershed. General soils data and map unit delineations for the United States are provided as part of the State Soil Geographic (STATSGO) database. The STATSGO data set was created to provide a general understanding of soils data to be used with large scale analyses. Small, site specific analyses with the STATSGO data are not appropriate. GIS coverages provide accurate locations for the soil map units at a scale of 1:250,000 (USDA, 1995). A map unit is composed of several soil series having similar properties. Identification fields in the GIS coverages can be linked to a database that provides information on chemical and physical soil characteristics. Figure 2-12 shows the general map unit boundaries in the Rosebud Creek watershed, and the following sections summarize relevant chemical and physical soil data.

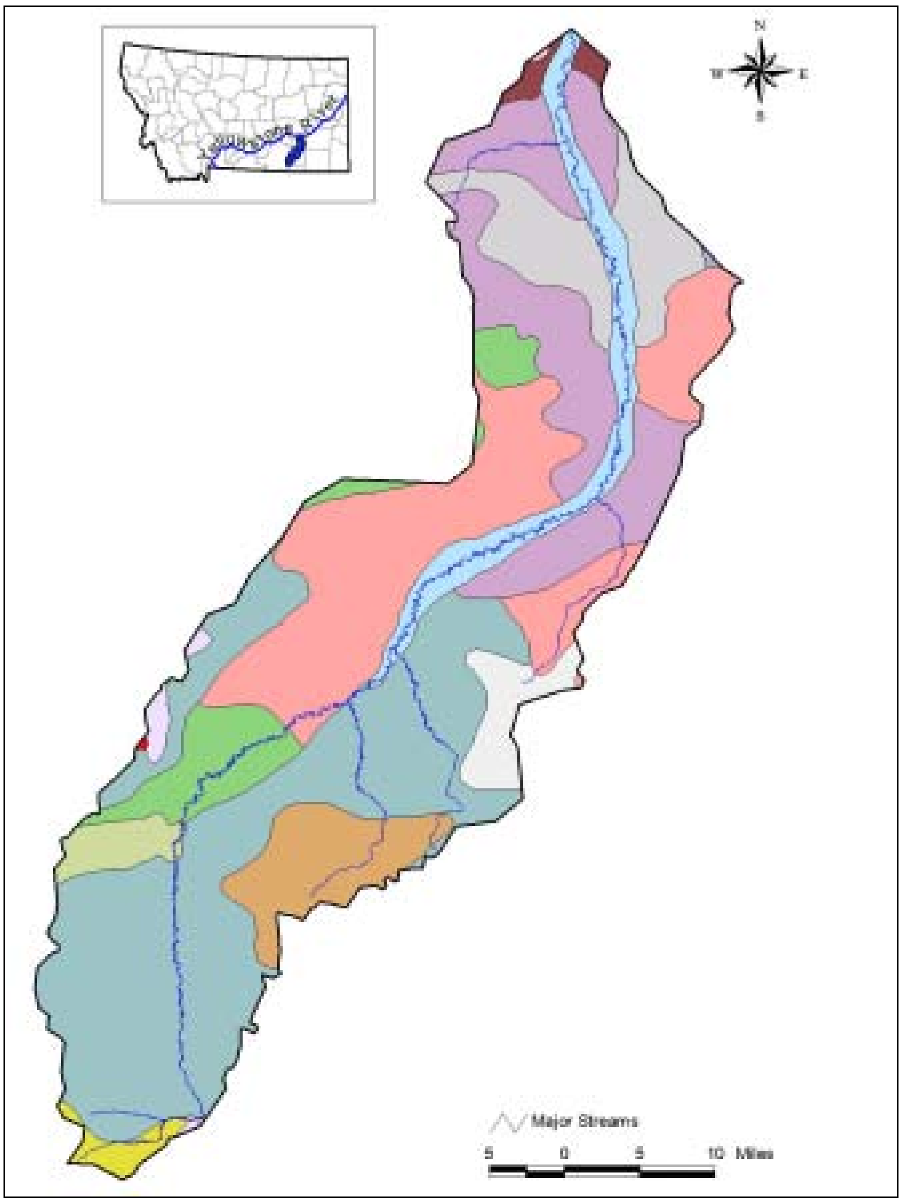

Figure 2-12. General soil units for the Rosebud Creek watershed.

2.1.9.1 Universal Soil Loss Equation (USLE) K-factor

A commonly used soil attribute is the K-factor, a component of the Universal Soil Loss Equation (Wischmeier and Smith, 1978). The K-factor is a dimensionless measure of a soil's natural susceptibility to erosion, and factor values may range from 0 for water surfaces to 1.00 (although in practice, maximum values do not generally exceed 0.67). Large K-factor values reflect greater inherently soil erodibility. The distribution of K-factor values in the Rosebud Creek watershed is shown in Figure 2-13. The figure indicates that nearly all of the soils in the watershed have K-factors ranging from 0.23 to 0.39, suggesting moderate soil erosion potential. The figure also shows that soils in the higher end of the moderate erosion susceptibility class (K-factors of 0.3 to 0.4) occur along the lower main stem of Rosebud Creek and throughout much of the upper portion of the watershed.

2.1.9.2 Hydrologic Soil Group

The hydrologic soil group classification is a means for grouping soils by similar infiltration and runoff characteristics during periods of prolonged wetting. Typically, clay soils that are poorly drained have the worst infiltration rates, while sandy soils that are well drained have the best infiltration rates. NRCS has defined four hydrologic groups for soils and data for the Rosebud Creek watershed were obtained from STATSGO (Table 2-7) (NRCS, 2001). Downloaded data were summarized based on the major hydrologic group in the surface layers of the map unit and are displayed in Figure 2-14.

The majority of soils in the Rosebud Creek watershed are alluvial B soils, characterized by moderately deep and moderately well drained soils with moderate infiltration rates. A large portion of soils in the lower Rosebud Creek watershed have high clay content typical of D soils. These areas typically have high rates of runoff resulting from poor infiltration rates. Only two small areas of fine textured C soils were found in the watershed. They are located in the headwaters of the watershed and near Busby.

Table 2-7. Hydrologic Soil Groups.

Hydrologic Soil Groups	Description
A	Soils with high infiltrations rates. Usually deep, well drained sands or gravels. Little runoff.
B	Soils with moderate infiltration rates. Usually moderately deep, moderately well drained soils.
C	Soils with slow infiltration rates. Soils with finer textures and slow water movement.
D	Soils with very slow infiltration rates. Soils with high clay content and poor drainage. High amounts of runoff.

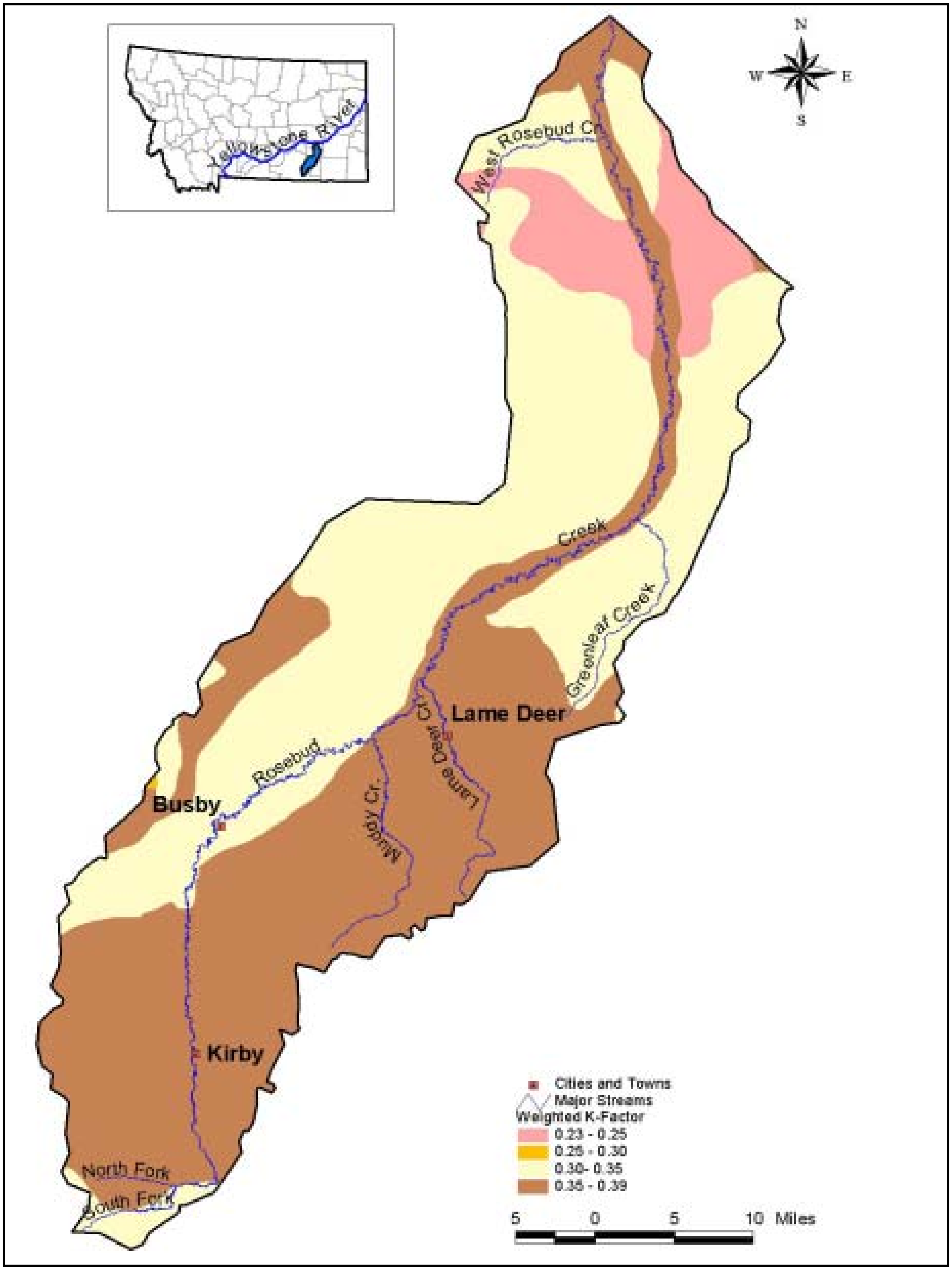

Figure 2-13. Distribution of the USLE K-factor.

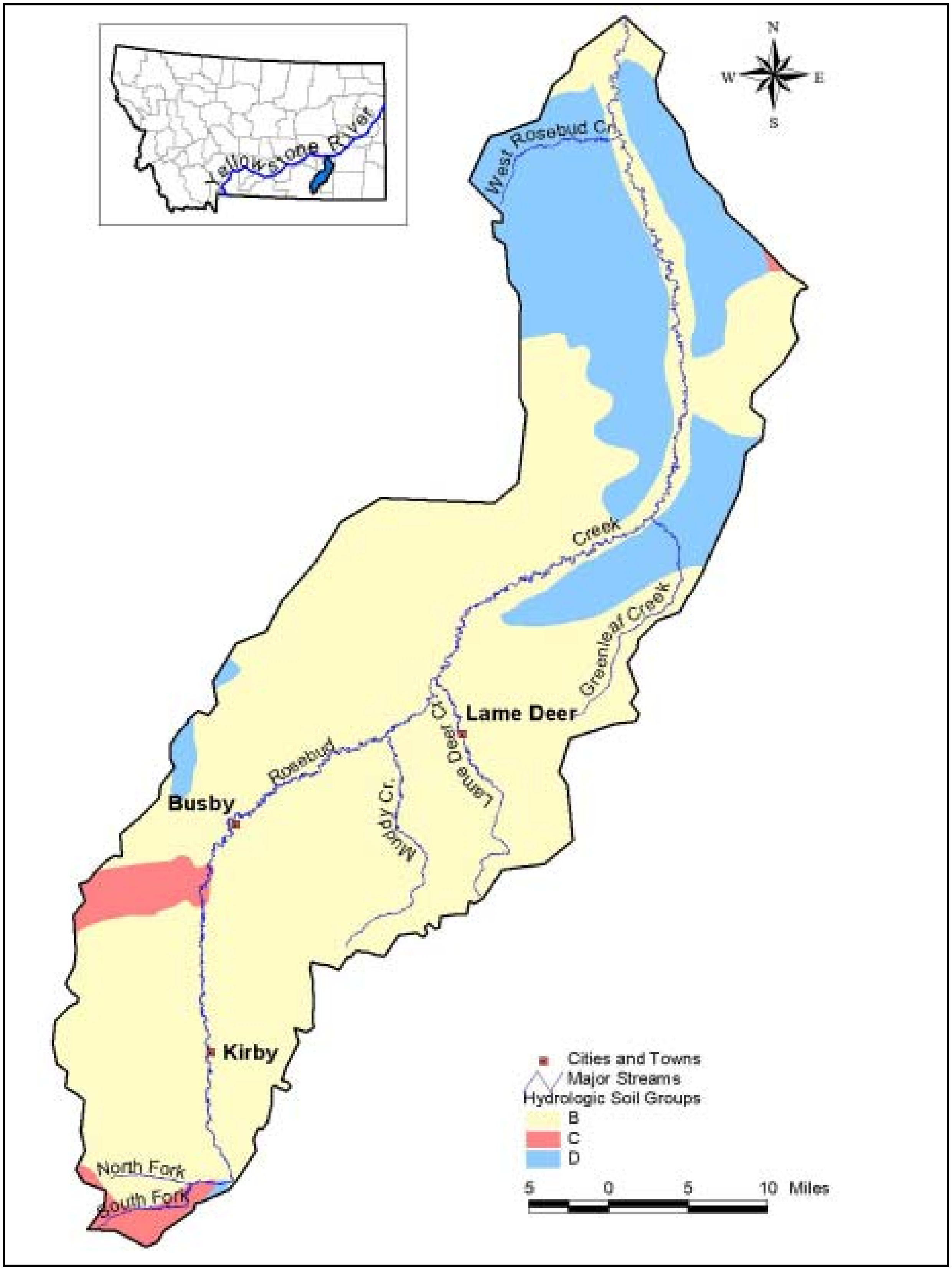

Figure 2-14. Distribution of hydrologic soil groups.

2.1.9.3 Permeability

Permeability is defined as the rate at which water moves through a soil. It is measured in inches per hour and varies with soil texture, structure, and pore sizes. Soil uses, such as agriculture, septic systems, and construction, can be limited when permeability is too slow. Clays are usually the least permeable soils and sands and gravels the most permeable. NRCS has provided the minimum and maximum ranges for permeability in the Rosebud Creek watershed in the STATSGO database. For the purpose of this analysis, permeabilities are reported for the surface layers of the dominant soil type in the STATSGO map units.

Figure 2-15 shows that minimum permeabilities in the Rosebud Creek watershed range from very slow to moderately rapid. Soils with the lowest permeabilities dominate the northern half of the watershed and continue into the southwestern region of the watershed. Most of the soils in the headwaters of Rosebud Creek have moderately rapid permeabilities.

2.1.9.4 Salinity

Salts are naturally occurring in the Rosebud Creek watershed due to bedrock materials that are easily weathered. These salts are found in varying concentrations in soils and waters throughout the watershed. In arid regions, salts also accumulate in soils due to evaporation that tends to concentrate salts in the upper soil layers. The term salts refers to several different anions and cations that may or may not be present in solution. The most common salts are calcium, magnesium, sodium, chloride, sulfate, and bicarbonate and they are usually measured in terms of electrical conductivity (EC) or total dissolved solids (TDS). NRCS classifies saline as having an electrical conductivity greater than 4,000 µS/cm. High salt concentrations in soil can limit the amount of plant available water and cause plant mortality, but this varies depending on the type of plant, soil, root depth, and salt depth.

Figure 2-16 shows the distribution of soil salt concentrations in the Rosebud Creek watershed. Data were obtained from the STATSGO database and represent the maximum salinity reported for the surface layer in the map unit. It should be noted that map units can be highly variable, and Figure 2-16 is meant as a general representation of salinity throughout the watershed. Electrical conductivities of 0 to 4,000 µS/cm dominate soils in the Rosebud Creek watershed. The areas with the lowest salinities are found along most of the main stem of Rosebud Creek, and near the town of Busby, Montana.

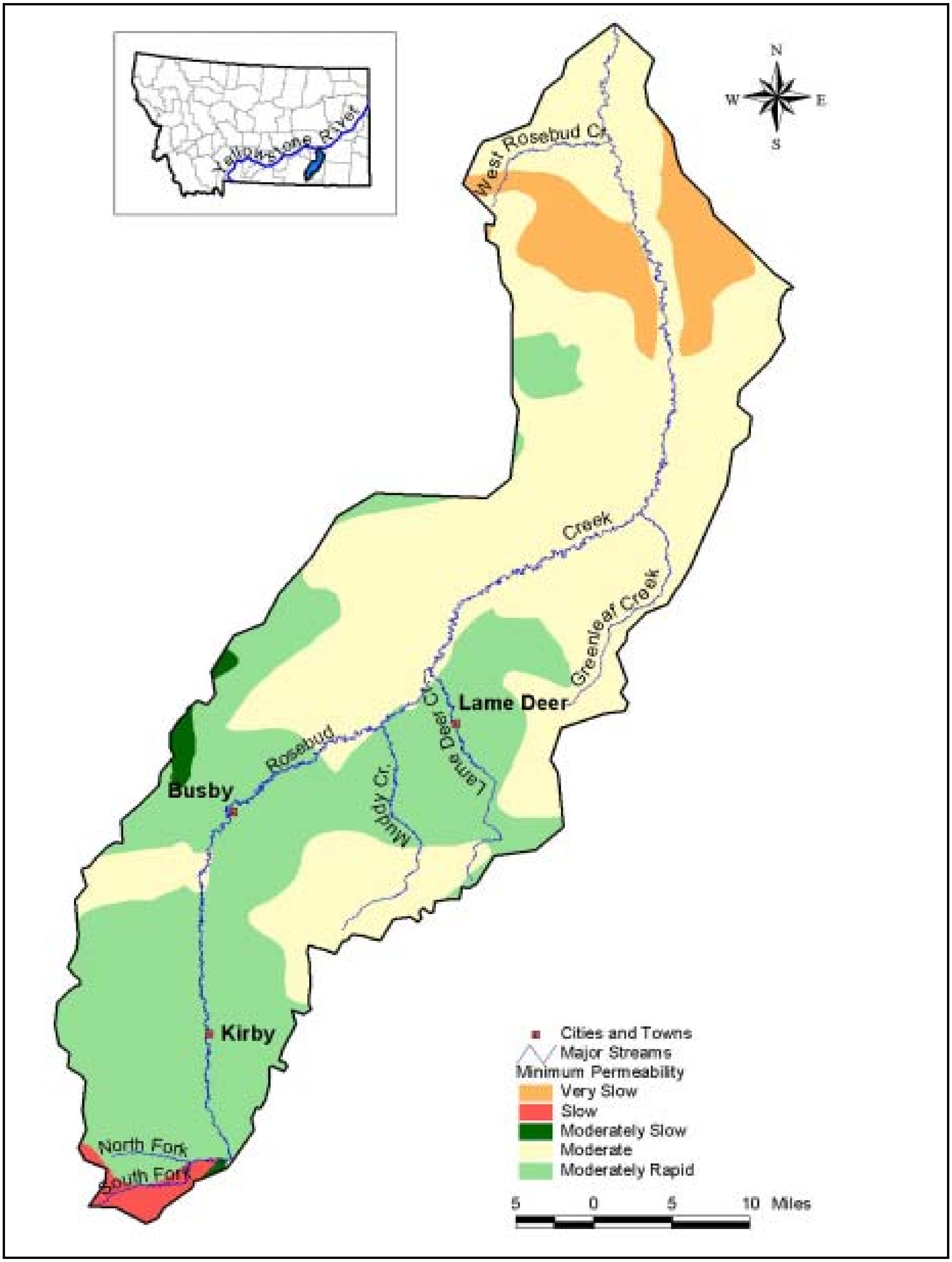

Figure 2-15. Distribution of soil permeabilities in the Rosebud Creek watershed.

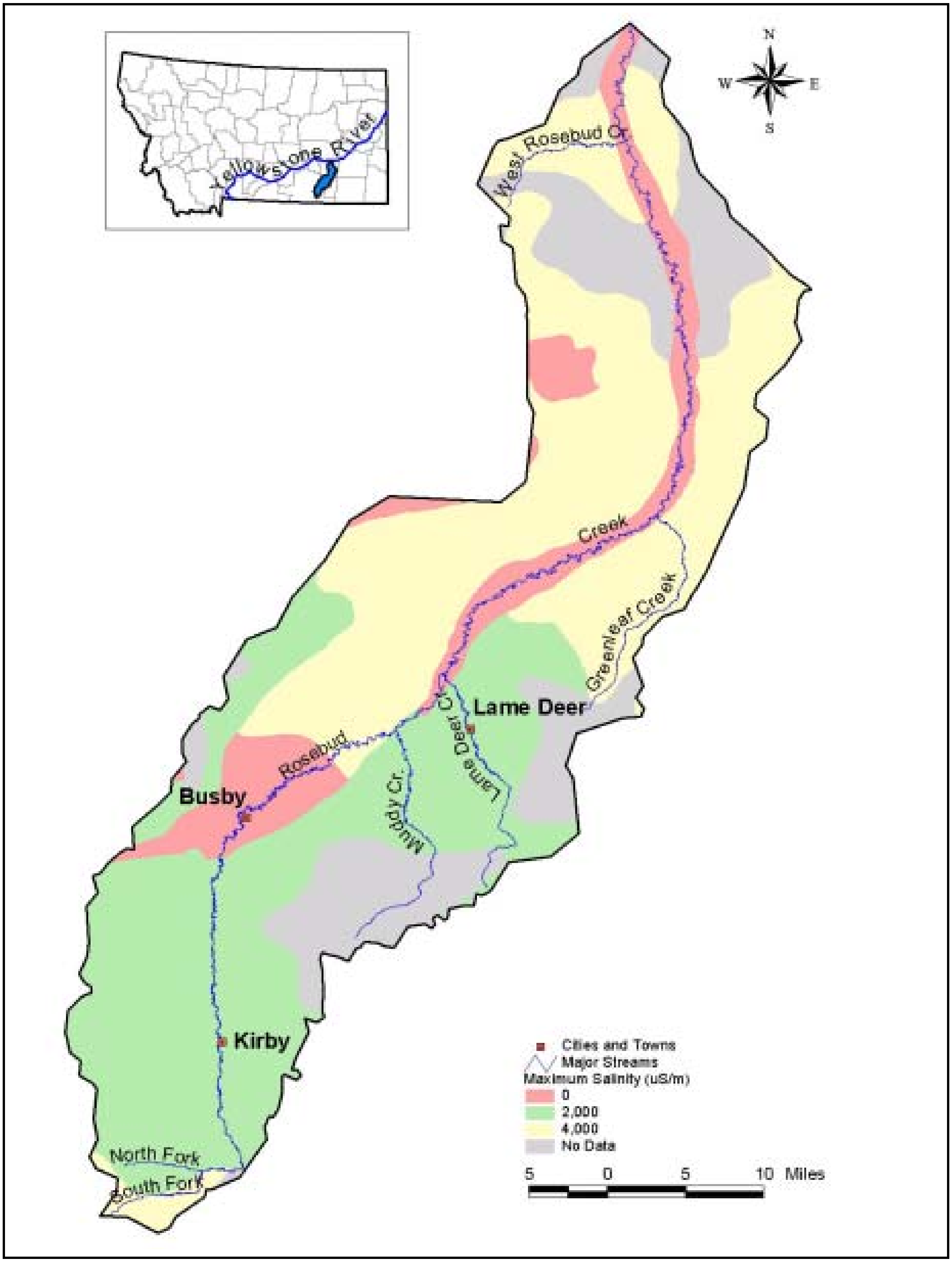

Figure 2-16. Distribution of soil salt concentrations in the Rosebud Creek watershed.

2.1.9.5 Sodium Adsorption Ratio

Sodium salts are naturally occurring in the Rosebud Creek watershed due to sodium-rich bedrock in certain areas. These salts make their way into soils through weathering processes and water transport. Due to evaporation, sodium then tends to accumulate in the soil surface layers and can have adverse effects on plants and soils. High sodium concentrations can disperse clay soils, changing the soil structure and rendering the soil hard and resistant to water and aeration. Sodium is also toxic to plants at elevated concentrations and raises the pH of a soil, which can also be toxic to plants.

Calcium and magnesium in the soil solution help to mitigate the effects of high sodium concentrations on soil structure. Because of this, a sodium adsorption ratio (SAR) is often used to determine the potential for sodium-caused impairment. SAR is the ratio of sodium to calcium plus magnesium in water. The units for the ions are milliequivalents per liter (meq/L). The exact ratio is shown below:

$$SAR = \frac{Na^{+}}{\sqrt{\dfrac{(Ca^{++} + Mg^{++})}{2}}}$$

Figure 2-17 shows the distribution of soil SAR values in the Rosebud Creek watershed. Data were obtained from the STATSGO database and represent the maximum SAR reported for the surface layer in the map unit. It should be noted that map units can be highly variable, and Figure 2-17 is meant as a general representation of the SAR throughout the watershed. There was little variability in the maximum SAR values for the soils in the Rosebud Creek watershed. All soils had maximum SAR values between 0 and 2.

2.1.9.6 Clay Content

The clay content of a soil affects the soil in many ways. Structure, texture, water holding capacity, and the mineral content of clay all help define the use of soil. In the Rosebud Creek watershed, clay content of the soil ranges from 27 to 60 percent (see Figure 2-18). Data for Figure 2-18 were obtained from the STATSGO database and represent the maximum clay content reported for the surface layer in the map unit. It should be noted that map units can be highly variable, and Figure 2-18 is meant as a general representation of the clay content throughout the watershed.

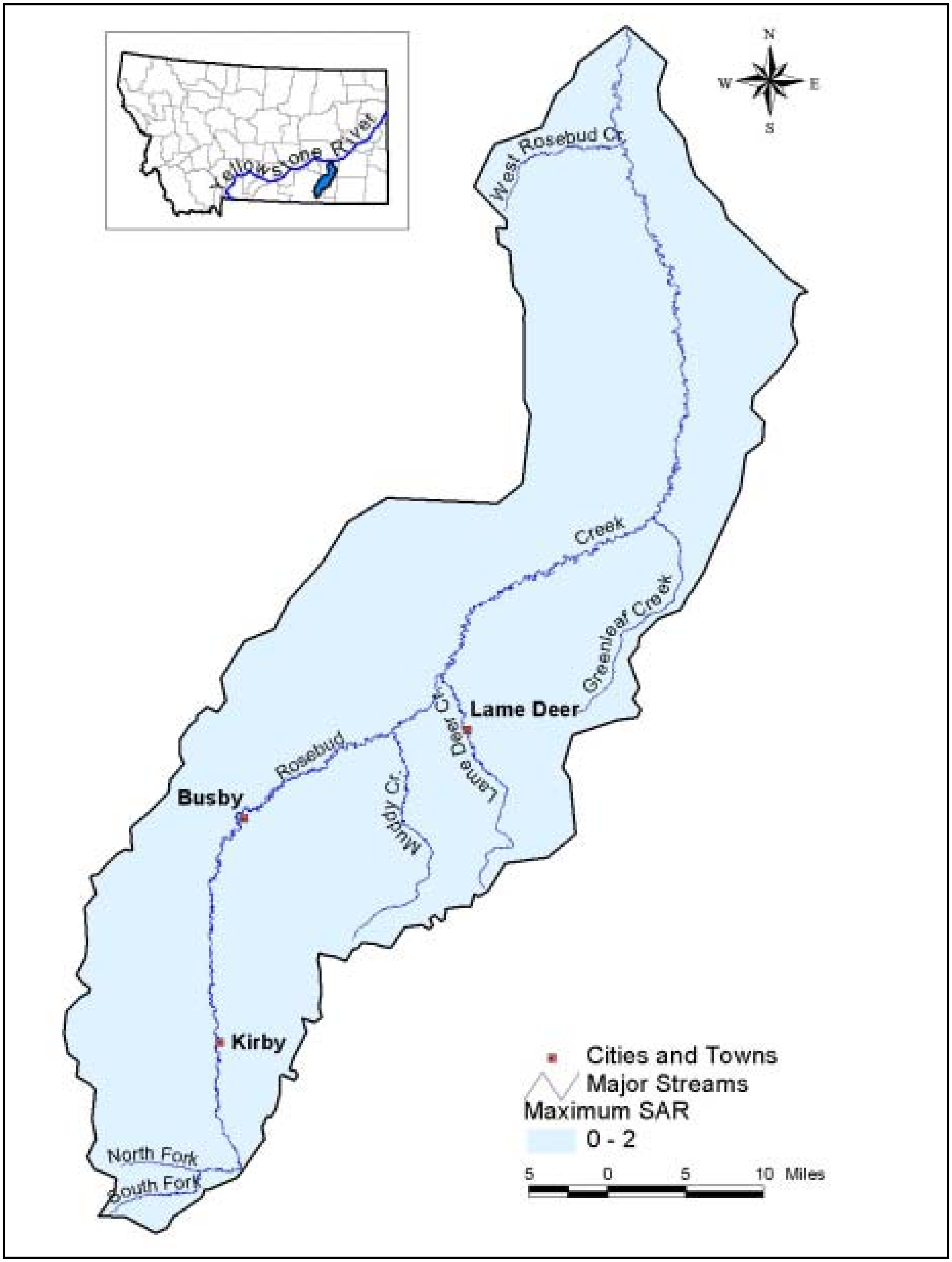

Figure 2-17. SAR for the Rosebud Creek watershed.

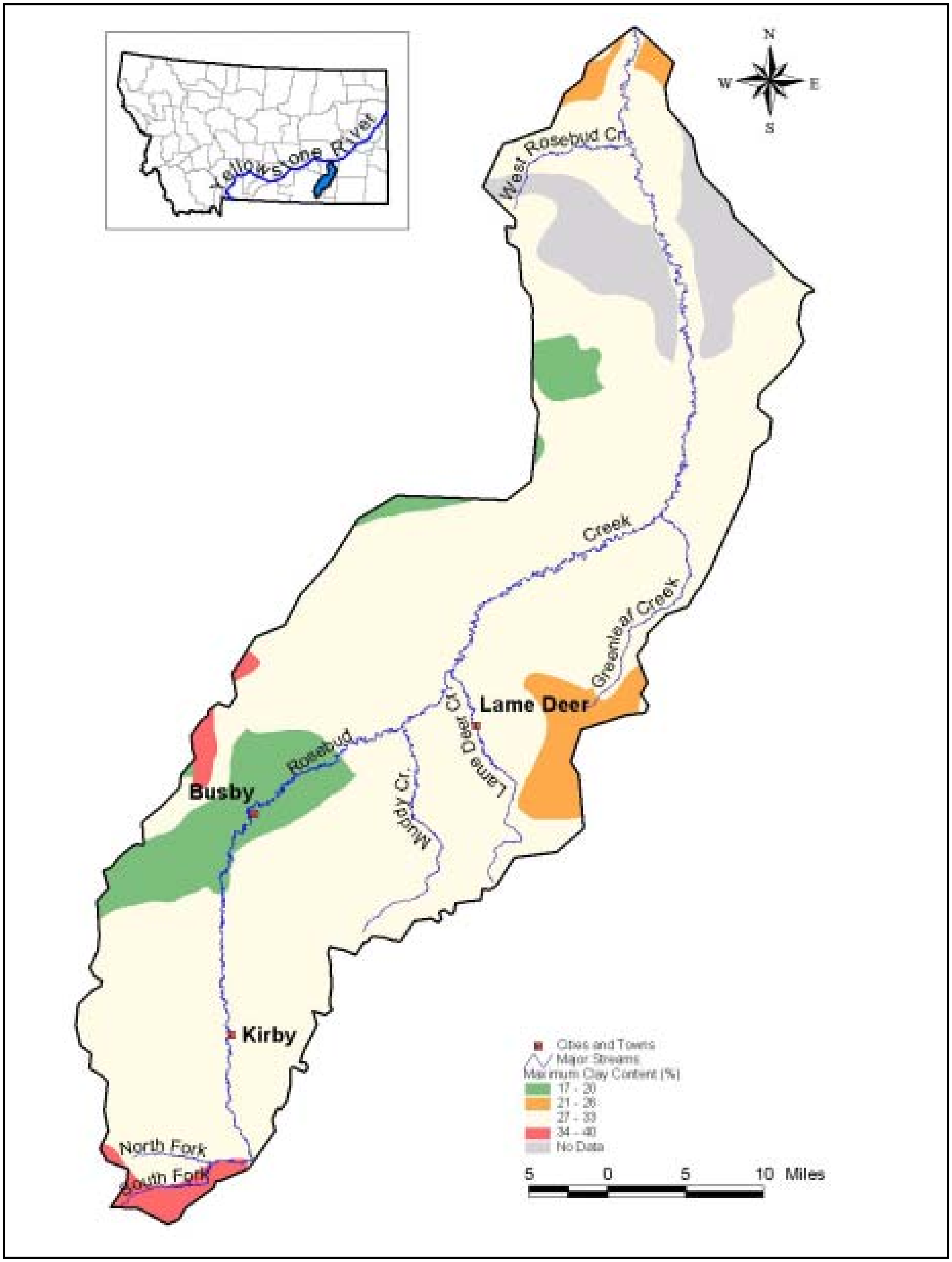

Figure 2-18. Soil clay content for the Rosebud Creek watershed.

2.1.10 Riparian vegetation characteristics

Vegetative characteristics within the riparian corridor of the Rosebud Creek watershed were examined by creating a 492-foot buffer (150-meter) on either side of the main stem and major tributaries of the Rosebud Creek in ArcView GIS. This buffer was then overlain on the GAP vegetative cover layer for the watershed, and the vegetative classes lying within the buffer were extracted. Table 2-8 gives the riparian vegetation characteristics for the Rosebud Creek watershed.

The buffering technique described above yielded a total of 29,863 riparian acres in the Rosebud Creek watershed (see Table 2-8). Of this area, 11,240 acres (37.64%) are in irrigated agricultural lands, 3,905 acres (13.08%) consist of shrub riparian, and another 2,896 acres (9.70 %) are in low to moderate cover grasslands. Additionally, dry agricultural lands, graminoid and forb riparian, and broad leaf riparian comprise 2,392 acres (8.01%), 2,366 acres (7.92%), and 1,277 acres (4.28%), respectively, within the riparian corridor.

Table 2-8. Vegetative characteristics within the riparian corridor of Rosebud Creek.

Land Use/Land Cover	Area		Percent
	Acres	Square Miles	
Agricultural Lands - Irrigated	11,240	17.6	37.64
Shrub Riparian	3,905	6.1	13.08
Low/Moderate Cover Grasslands	2,896	4.5	9.70
Agricultural Lands - Dry	2,392	3.7	8.01
Graminoid and Forb Riparian	2,366	3.7	7.92
Broadleaf Riparian	1,277	2.0	4.28
Ponderosa Pine	1,225	1.9	4.10
Low Density Xeric Forest	1,027	1.6	3.44
Mixed Xeric Shrubs	789	1.2	2.64
Moderate/High Cover Grasslands	634	1.0	2.12
Mixed Mesic Shrubs	580	0.9	1.94
Sagebrush	348	0.5	1.17
Mixed Riparian	282	0.4	0.95
Mesic Shrub-Grassland Associations	196	0.3	0.66
Mixed Broadleaf Forest	156	0.2	0.52
Mixed Broadleaf and Conifer Riparian	150	0.2	0.50
Mixed Barren Sites	78	0.1	0.26
Very Low Cover Grasslands	74	0.1	0.25
Badlands	70	0.1	0.23
Mixed Broadleaf and Conifer Forest	68	0.1	0.23
Urban or Developed Lands	54	0.1	0.18
Xeric Shrub-Grassland Associations	26	0.0	0.09
Water	22	0.0	0.07
Silver Sage	6	0.0	0.02
Total	29,863	46.7	100.00

2.2 Cultural Characteristics

2.2.1 Population

The total population for the watershed is not directly available but may be inferred from the 2000 U.S. Census data. The 2000 U.S. Census data were downloaded for all towns, cities and counties whose boundaries lie wholly or partially within the watershed. Urban populations for each county were determined by summing the populations of all towns and cities located within the watershed. Nonurban populations for each county were determined by first subtracting the county urban population totals from the county population total. Since only portions of various counties are found within the watershed, a nonurban population weighting method was used to estimate each county's contribution of nonurban population to the total watershed population. The proportion of county area within the watershed was determined from spatial overlay of county boundaries and the watershed boundary in a geographic information system (GIS). It is assumed that the nonurban population for each county is uniformly distributed within the county. The nonurban county population was multiplied by the county's proportional watershed area and the product was assumed to reflect the county nonurban population.

The analysis found that approximately 3,173 people reside within the Rosebud Creek watershed. The watershed urban and nonurban population totals by county are given in Table 2-9. Figure 2-1 displays the locations of counties and the larger cities and towns. From the table, it can be seen that 834 people, or 26.30 percent of the population, live in nonurban areas, while 2,339 people (73.70 percent) reside in cities and towns. Rosebud County has the largest total population in the watershed with 2,082 people (65.61 percent of the watershed total population), and it also has the largest urban population of 1,867, or roughly 59 percent of the entire urban population within the watershed. Big Horn County represents 34.39 percent of the watershed population with 619 people (19.52 percent) and 472 people (14.87 percent) living in non-urban and urban areas, respectively.

Urban population centers in the Rosebud Creek watershed are listed in Table 2-10. The total urban population in the watershed is 2,339 people, distributed among three towns, each with small populations. The largest town is Lame Deer, in Rosebud County with 1,867 people. The other towns, Busby and Kirby, located in Big Horn County have populations of 452 people and 20 people, respectively.

Table 2-9. Rosebud Creek watershed population summarized by county.

County	Total Watershed Population	Percent of Total Population	Non-urban Population	Percent Non-urban	Urban Population	Percent Urban
Big Horn	1,091	34.39	619	19.52	472	14.87
Rosebud	2,082	65.61	215	6.78	1,867	58.83
Total	3,173	100.00	834	26.30	2,339	73.70

Source: U.S. 2000 Census and GIS analysis.

Table 2-10. Urban population centers in the Rosebud Creek watershed.

City/Town	Population	County
Kirby	20	Big Horn
Busby	452	Big Horn
Lame Deer	1,867	Rosebud
Total Urban Population	2,339	

Source: U.S. 2000 Census and GIS analysis.

2.2.2 Land Ownership

Various private, tribal, state and federal agencies hold title to portions of the Rosebud Creek watershed, as shown in Table 2-11 and Figure 2-19. For the watershed as a whole, the majority of land is privately owned, encompassing 463,055 acres, or 55.47 percent of the watershed area. Tribal land ownership, represented by the Crow and Northern Cheyenne tribal lands, comprises 322,345 acres or roughly 39 percent of the watershed area. Individually, Northern Cheyenne tribal lands account for 266,003 acres (31.86 percent), whereas, 56,342 acres (6.75 percent) are held by Crow tribal lands. Furthermore, the Montana Department of Natural Resources and Conservation and Bureau of Land Management govern 24,220 acres (2.90 percent) and 22,454 acres (2.69 percent), respectively. The remaining ownership in the watershed accounts for less than one percent of total ownership (approximately 2,700 acres).

Table 2-11. Land Ownership in the Rosebud Creek Watershed.

	Area		
Land Ownership Description	Acres	Square Miles	Percent
Private Lands	463,055	723.5	55.47
Northern Cheyenne Tribal Lands	266,003	415.6	31.86
Crow Tribal Lands	56,342	88.0	6.75
Dept of Natural Resources & Conservation	24,220	37.8	2.90
Bureau of Land Management	22,454	35.1	2.69
Montana Fish Wildlife & Parks	2,540	4.0	0.30
Montana State Lands (Water)	235	0.4	0.03
Total	834,849	1,304.5	100.00

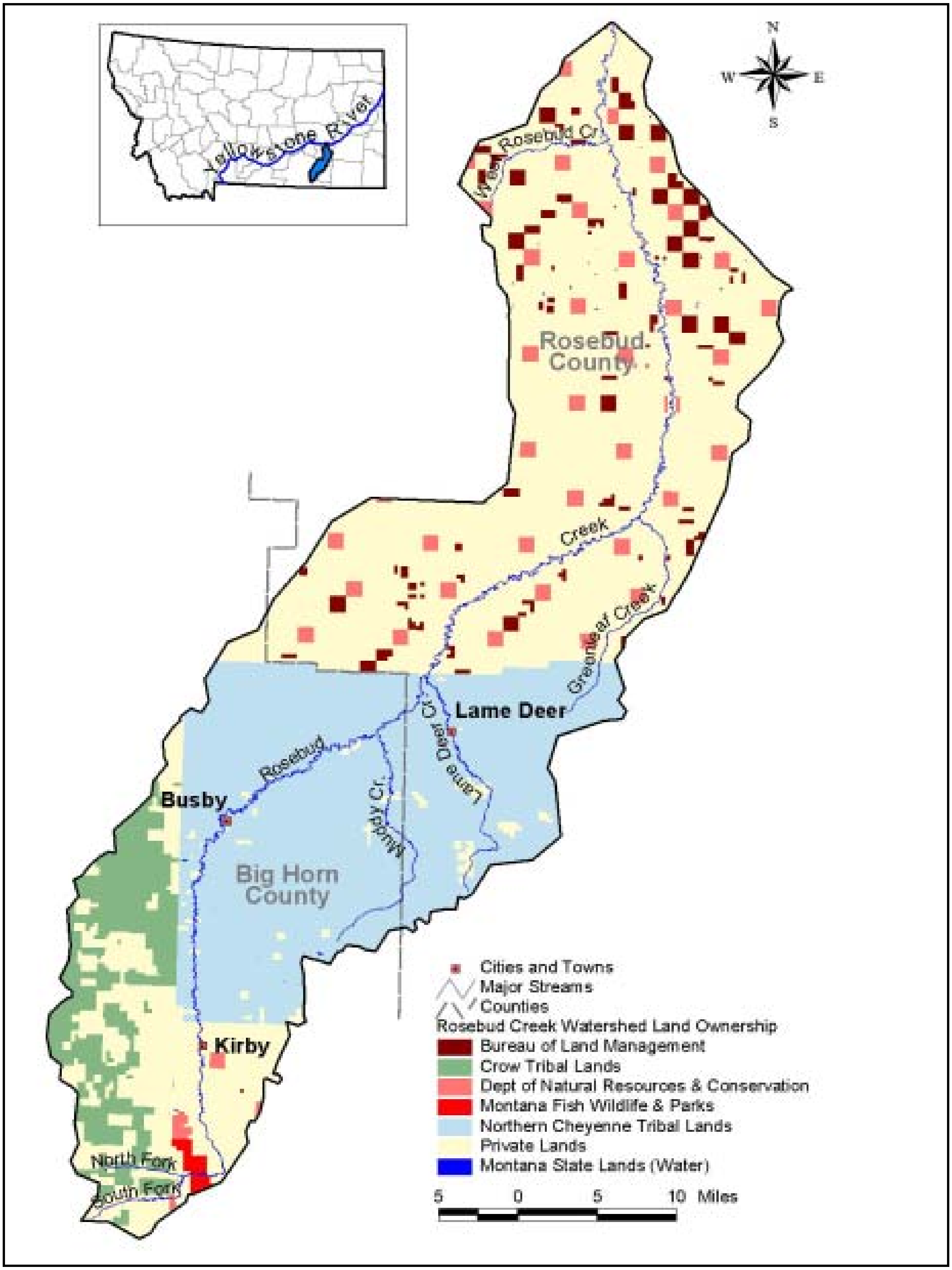

Figure 2-19. Land Ownership in the Rosebud Creek watershed.

2.2.3 Economics

The two counties in the Rosebud Creek watershed in Montana – Big Horn County and Rosebud County – both support a primarily rural economy. Big Horn County has the most number of people and the largest workforce of the two counties (Table 2-12). Unemployment rates in 2000 were above the state average of 4.9 percent in Big Horn and Rosebud Counties (Table 2-13). Both the Northern Cheyenne and Crow Reservations also had unemployment rates above the Montana state average (MDLI, 2001).

The median income in 2000 for Big Horn and Rosebud Counties was $30,000 and $27,684, respectively (U.S. Census Bureau, 2000). Most people in Rosebud and Big Horn counties were employed by the educational, health, and social services sector (U.S. Census Bureau, 2000) (Table 2-14). A large percentage of people also worked in the agriculture, forestry, fishing, hunting, and mining industry in both counties. Table 2-15 summarizes the agricultural economics data for each county in the Rosebud Creek watershed. On average, almost 40 million dollars in revenue for agricultural products were generated per county in 1997 (NASS, 1997).

Table 2-12. Summary of population and work force data per county.

County	Total Population	Total Population Greater than 15 Years Old	Number of People in the Labor Force	Total Number of Households
Big Horn	12,671	8,680	5,431	3,924
Rosebud	9,383	6,611	4,288	3,307
Reservation				
Crow Reservation	10,083	NA	3,902	NA
Northern Cheyenne Reservation	7,473	NA	2,437	NA

Sources: U.S. Census Bureau, 2000; USDI, 2003.
Note: Population data are presented for the entire county, not just the portion within the Rosebud Creek watershed.

Table 2-13. Unemployment rates by county and reservation.

County	1995 Rate (%)	2000 Rate (%)	% Change
Big Horn	12.7	14.4	1.7
Rosebud	9.2	7.5	-1.7
Reservation	**1996 Rate (%)**	**1999 Rate (%)**	**% Change**
Crow Reservation	15.5	14.9	0.6
Northern Cheyenne Reservation	26.0	18.7	7.3

Source: MDLI, 2001 (adapted from USDI, 2002).
Note: Unemployment data are presented for the entire county, not just the portion within the Rosebud Creek watershed.

Table 2-14. Percent employment by sector in 2000.

Industry	Rosebud County	Big Horn County
Agriculture, forestry, fishing, hunting, and mining	19.6	14.6
Construction	4.8	6.7
Manufacturing	1.6	0.8
Wholesale trade	0.6	1.2
Retail trade	6.6	8.9
Transportation/warehousing/utilities	11.6	3.2
Information	2.1	0.5
Finance, insurance, real estate, and rental and leasing	2.2	3.5
Professional, scientific, management, administrative, and waste management services	2.8	2.9
Educational, health and social services	28.1	31.1
Arts, entertainment, recreation, accommodation and food services	9.2	9.0
Other services (except public administration)	3.9	2.7
Public administration	6.9	15

Source: U.S. Census Bureau, 2000.
Note: Employment data are presented for the entire county, not just the portion within the Rosebud Creek watershed.

Table 2-15. Summary of agricultural economics data for 1997.

	Big Horn County	Rosebud County
Farms (number)	530	362
Land in farms (acres)	2,770,118	2,680,844
Total cropland (acres)	407,958	122,605
Market value of agricultural products sold	$61,126,000	$37,666,000
Market value of agricultural products sold, average per farm	$115,332	$104,049

Source: NASS, 1997.
Note: Agricultural data are presented for the entire county, not just the portion within the Rosebud Creek watershed.

2.3 Fisheries

The Montana Fisheries Information System (MFISH) contains information on fish species in Montana's rivers. Fish species potentially found in Rosebud Creek are shown in Table 2-16. MFISH classified most of Rosebud Creek as a high-value fishery (MFISH, 2002).

Table 2-16. Fish species in Rosebud Creek.

Species	River Mile (rm)	Abundance	Water Use
Black Bullhead	From (rm 0.0) to (rm 207.6)	Rare	Year-round resident
Brook Trout	From (rm 0.0) to (rm 207.6)	Rare	Year-round resident
Burbot	From (rm 0.0) to (rm 183.1)	Common	Year-round resident
Channel Catfish	From (rm 0.0) to (rm 183.1)	Common	Year-round resident
Common Carp	From (rm 0.0) to (rm 207.6)	Common	Year-round resident
Fathead Minnow	From (rm 0.0) to (rm 207.6)	Rare	Year-round resident
Flathead Chub	From (rm 0.0) to (rm 207.6)	Abundant	Year-round resident
Goldeye	From (rm 0.0) to (rm 183.1)	Rare	Year-round resident
Lake Chub	From (rm 0.0) to (rm 207.6)	Rare	Year-round resident
Longnose Dace	From (rm 0.0) to (rm 207.6)	Common	Year-round resident
Longnose Sucker	From (rm 0.0) to (rm 183.1)	Rare	Year-round resident
Mountain Sucker	From (rm 0.0) to (rm 207.6)	Rare	Year-round resident
Northern Pike	From (rm 0.0) to (rm 207.6)	Common	Year-round resident
River Carpsucker	From (rm 0.0) to (rm 183.1)	Rare	Year-round resident
Sauger	From (rm 0.0) to (rm 183.1)	Common	Primarily spawning and rearing
Shorthead Redhorse	From (rm 0.0) to (rm 207.6)	Abundant	Year-round resident
Stonecat	From (rm 0.0) to (rm 207.6)	Rare	Year-round resident
Walleye	From (rm 0.0) to (rm 183.1)	Rare	Primarily spawning and rearing
White Crappie	From (rm 0.0) to (rm 183.1)	Rare	Year-round resident
White Sucker	From (rm 0.0) to (rm 207.6)	Common	Year-round resident

Source: MFISH, 2002.

3.0 WATER QUALITY CONCERNS AND STATUS

This section of the document first presents the 303(d) list status of all listed water bodies within the TPA (i.e., which water bodies are listed as impaired or threatened and for which pollutants). This is followed by a description of the parameters of concern, the applicable water quality standards, a water body by water body review of available water quality data, and, finally, an updated water quality impairment status determination for each listed water body.

3.1 Montana 303(d) List Status

The Montana 1996 303(d) list reported that beneficial uses in Rosebud Creek were impaired for a variety of reasons. The listing information from the report is shown in Table 3-1. A revised listing for Rosebud Creek appeared on Montana's 2002 303(d) lists (Table 3-2). Figure 3-1 shows the location of the Rosebud Creek watershed, major streams, and the impaired river segments from the 1996 303(d) list.

Table 3-1. 1996 listing information for Rosebud Creek.

Segment Name	Estimated Size (mi)	Probable Impaired Uses	Probable Cause	Probable Source
Rosebud Creek (Lower and Middle Rosebud Creek)	114	Aquatic life Warmwater fishery	Flow Alteration Suspended Solids Salinity/TDS/Chlorides Other Inorganics Nutrients Metals	Agriculture Natural Sources Irrigated Crop Production

Source: MDEQ, 1996.

Table 3-2. 2002 listing information for Rosebud Creek.

Segment Name	Size (mi)	Use Status[a]	Probable Cause	Probable Source
Rosebud Creek - from the mouth 3.8 miles upstream to an irrigation dam (Lower Rosebud Creek)	3.8	Agriculture (not assessed) Aquatic life (partial) Fishery (partial) Industrial (not assessed) Recreation (not assessed)	Bank erosion Other habitat alterations	Removal of riparian vegetation Habitat modification
Rosebud Creek - from the Northern Cheyenne Reservation boundary to the irrigation dam (Middle Rosebud Creek)	105.8	Agriculture (not assessed) Aquatic life (not assessed) Fishery (partial) Industrial (not assessed) Recreation (not assessed)	Other Nutrients	Dam construction Hydromodification
Rosebud Creek – Northern Cheyenne Reservation	73.5	Agriculture (not assessed) Aquatic life (not assessed) Fishery (not assessed) Industrial (not assessed) Recreation (not assessed)		
Rosebud Creek – from the headwaters to the southern border of the Northern Cheyenne Reservation (Upper Rosebud Creek)	22.8	Agriculture (not assessed) Aquatic life (not assessed) Fishery (not assessed) Industrial (not assessed) Recreation (not assessed)		

[a]Not all uses have been assessed.
Source: MDEQ, 2002a.

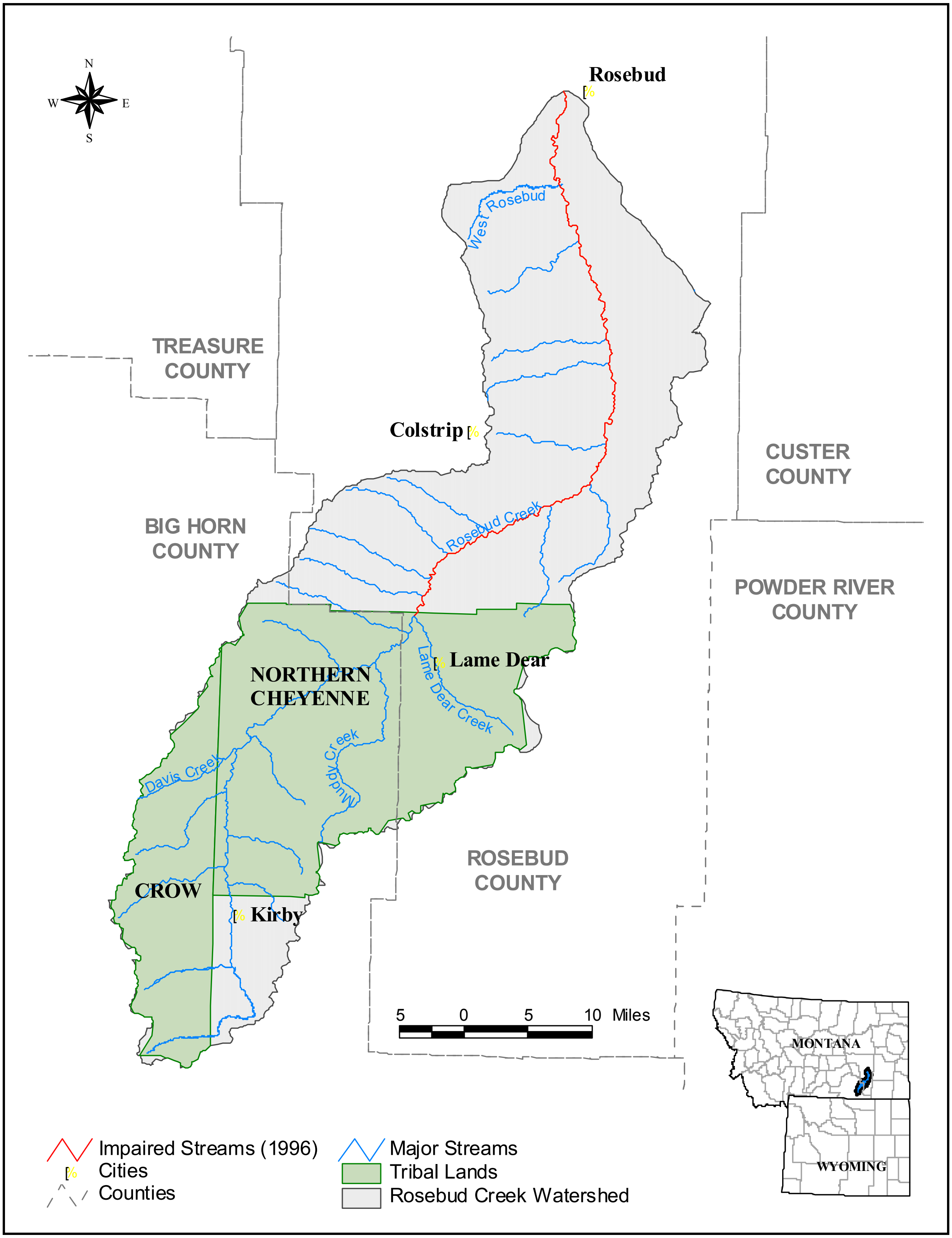

Figure 3-1. Location of 1996 impaired streams in the Rosebud Creek watershed.

3.2 Parameters of Concern

The following sections provide a summary of the parameters identified on the Montana 1996 303(d) list as causing impairments in Rosebud Creek. The purpose of these sections is to provide an overview of the parameters, units, sampling methods, and potential sources. The relevance of the parameter to the various beneficial uses is also briefly discussed.

3.2.1 Salinity and Total Dissolved Solids

As water flows through a system, particles of soil, rock, and other materials accumulate in the water. The materials dissolve (or dissociate) in the water to form cations (positively charged ions) and anions (negatively charged ions). The term *salinity* refers to the total amount of dissolved cations and anions in water. Major ions in water are generally sodium, calcium, magnesium, potassium, chloride, sulfate, and bicarbonate. Metals (e.g., copper, lead, and zinc) and other trace elements (e.g., fluoride, boron, and arsenic) are usually only minor components of the total salinity. Salinity is determined by measuring the *conductance* of water, which is the opposite of resistance. This is done by sending an electrical current through the water and measuring the *electrical conductivity* (EC). The conductance of the water is corrected to a water temperature of 25 °C, and is sometimes then called *specific conductivity* (SC). In this report, all EC values are corrected to a water temperature of 25 °C. The units for EC are typically microsiemens per centimeter (µS/cm). EC is an easy and cost efficient measurement that can be performed in the field or the laboratory.

The sum of all of the dissolved substances in water is called *total dissolved solids* (TDS), and is measured in milligrams per liter (mg/L). TDS is a laboratory measurement and cannot be determined in the field. Pure distilled water has a TDS of zero. TDS concentrations in rainfall and snowfall vary, and generally range from zero to 10 milligrams per liter.

The salinity of a waterbody is important to many aquatic organisms because it regulates the flow of water into an out of an organism's cells (osmosis). Increases or decreases in salinity can cause a shift in the composition of the natural aquatic community. In Rosebud Creek, it is likely that many native aquatic organisms have adapted to the natural moderate salinity. The effects of salinity on non-native species (such as northern pike and rainbow trout) are unknown. Highly saline waters can adversely affect crop production depending on the amount of water applied and the salt tolerance of the crop. Livestock can also be adversely affected by high salinity values.

Natural sources, such as geology and soils, contribute to the salinity of a stream. Watersheds that have easily erodible soils, or parent materials with high salt concentrations, have streams and lakes that have naturally high salinity. However, there are also several potential anthropogenic sources of salinity. Anthropogenic sources of salinity can occur from agricultural irrigation returns, oil and gas returns (e.g., CBM wells and oil wells), disturbed land, road salting, and agricultural runoff. Proposed CBM development in the Rosebud Creek watershed is a major potential source of salinity. Monitoring data reported by one CBM operating facility in the Tongue River watershed in Montana indicates a mean salinity of 2,207 µS/cm.

3.2.2 Chlorides

Chloride salts are common in the earth's crust and are easily dissolved in water. Sodium chloride is one such salt, and other major chloride salts are calcium chloride and magnesium chloride. These salts accumulate and dissolve in water as it flows through a watershed. Chloride concentrations are measured in the lab and are typically reported in milligrams per liter. Chloride is one of the many salts measured by salinity and TDS. Therefore any increases or decreases in the chloride concentrations of a waterbody will also cause changes in the salinity and TDS.

Chloride salts are one portion of the salinity of water, and the salinity of a waterbody is important to many aquatic organisms because it regulates the flow of water into an out of an organism's cells (osmosis). In Rosebud Creek, it is likely that many native aquatic organisms have adapted to the natural moderate chloride concentrations. The effects of chlorides on non-native species (such as northern pike and rainbow trout) are unknown. Chlorides alone can also be toxic to aquatic organisms (USEPA, 1988). Irrigation water with high chloride concentrations can adversely affect crop production depending on the amount of water applied and the salt tolerance of the crop. Livestock can also be adversely affected by high chloride concentrations.

Natural sources, such as geology and soils, contribute to the chloride concentrations of a stream. There are also several potential anthropogenic sources of chlorides. Potential anthropogenic sources of chlorides are irrigation returns, oil and gas returns (e.g., CBM wells, oil wells), road salting, and urban and agricultural runoff.

3.2.3 Sodium Adsorption Ratio

Sodium, magnesium, and calcium salts are naturally occurring in the bedrock and soils of the Rosebud Creek watershed. These salts make their way into streams through weathering processes, runoff, and percolation. The concentrations of calcium, magnesium, and sodium ions in water are of interest because of the way they interact with soils. When high sodium concentrations are present in water with low calcium and magnesium concentrations, the sodium ions can disperse clay soils. This can change the soil structure and eventually render the soil hard and resistant to water and aeration. The relationship between calcium, magnesium, and sodium in streams is monitored to protect the agricultural uses of the waterbody. The relationship is called the sodium adsorption ratio (SAR), and it is the ratio of sodium to calcium plus magnesium in water. It is calculated with the following formula and the units for the ions are milliequivalents per liter (meq/L). The calculated values for SAR are unitless because it is a ratio.

$$SAR = \frac{Na^{+}}{\sqrt{\frac{(Ca^{++} + Mg^{++})}{2}}}$$

The SAR only impacts agricultural uses of a waterbody. The effect of high SAR values on aquatic life, livestock, or drinking water uses is unknown. Individually, calcium, magnesium, and sodium salts all contribute to the salinity of a waterbody.

Natural sources, such as geology and soils, contribute calcium, magnesium, and sodium to waterbodies and therefore affect the SAR. Potential anthropogenic sources of calcium, magnesium, and sodium can occur from agricultural irrigation returns, oil and gas returns (e.g., CBM wells, oil wells), disturbed land, road salting, and urban and agricultural runoff. Anthropogenic sources can increase the SAR by contributing high sodium loads to a waterbody. Proposed CBM development in the Rosebud Creek watershed is a major potential source of SAR. Monitoring data reported by one CBM operating facility in the Tongue River watershed in Montana indicates a mean SAR of approximately 47.

3.2.4 Nutrients/Organic Enrichment/Low Dissolved Oxygen

The term *nutrients* usually refers to the various forms of nitrogen and phosphorus found in a waterbody. Both nitrogen and phosphorus are necessary for aquatic life, and both elements are needed at some level in a waterbody to sustain life. The natural amount of nutrients in a waterbody varies depending on the type of system. A pristine mountain spring might have little to almost no nutrients, whereas a lowland, mature stream flowing through wetland areas might have naturally high nutrient concentrations. Various forms of nitrogen and phosphorus can exist at one time in a waterbody, although not all forms can be used by aquatic life. Common phosphorus sampling parameters are total phosphorus (TP), dissolved phosphorus, and orthophosphate. Common nitrogen sampling parameters are total nitrogen (TN), nitrite (NO_2), nitrate (NO_3), total Kjeldahl nitrogen (TKN), and ammonia (NH_3). Concentrations are measured in the lab and are typically reported in milligrams per liter.

Nutrients generally do not pose a direct threat to the beneficial uses of a waterbody. However, excess nutrients can cause an undesirable abundance of plant and algae growth. This process is called eutrophication or organic enrichment. Organic enrichment can have many effects on a stream or lake. One possible effect of eutrophication is low dissolved oxygen concentrations. Aquatic organisms need oxygen to live and they can experience lowered reproduction rates and mortality with lowered dissolved oxygen concentrations. Dissolved oxygen concentrations are measured in the field and are typically reported in milligrams per liter. Ammonia, which is toxic to fish at high concentrations, can be released from decaying organic matter when eutrophication occurs. Recreational uses can be impaired because of eutrophication. Nuisance plant and algae growth can interfere with swimming, boating, and fishing. Nutrients generally do not pose a threat to agricultural uses.

Nitrogen and phosphorus exist in rocks and soils and are naturally weathered and transported into waterbodies. Organic matter is also a natural source of nutrients. Systems rich with organic matter (e.g., wetlands and bogs) can have naturally high nutrient concentrations. Phosphorus and nitrogen are potentially released into the environment through different anthropogenic sources including septic systems, wastewater treatment plants, fertilizer application, and animal feeding operations.

3.2.5 Metals

The metals of concern for Rosebud Creek are cadmium, chromium, copper, iron, lead, nickel, silver, and zinc. For the purpose of this report, arsenic and selenium are also analyzed with the metals data. The procedures used to sample metals in the field and analyze metals in the laboratory have changed substantially over time. General speculation is that historical metals sampling results are often questionable because of possible contamination during collection and processing. New metals procedures set by USEPA have been implemented to ensure clean sampling results (USEPA, 1996). Analytical procedures in the laboratory now have better accuracy and lower detection limits, and smaller metals concentrations can be detected. Because some data are questionable, only metals data from 1996 to present are analyzed in this report. Metals data are typically reported in micrograms per liter (µg/L).

Metals usually present a threat to the health of aquatic life, animals, and humans because of toxicity. The toxic effects of some metals change with the hardness of water. The effects on agricultural uses of water are not well known.

Potential sources of metals include natural sources (e.g., geology and soils) and anthropogenic sources such as industrial discharges, CBM, oil, and coal mine discharges, wastewater treatment plants, septic systems, and urban runoff.

3.2.6 Total Suspended Solids

Excess total suspended solids (TSS) in a stream can pose a threat to aquatic organisms. Turbid waters created by excess TSS concentrations reduce light penetration, which can adversely affect aquatic organisms. Also, TSS can interfere with fish feeding patterns because of the turbidity. Prolonged periods of very high TSS concentrations can be fatal to aquatic organisms (Newcombe and Jensen, 1996). As TSS settles to the bottom of a stream, critical habitats such as spawning sites and macroinvertebrate habitats can be covered in sediment. This is referred to as siltation. Excess sediment in a stream bottom can reduce dissolved oxygen concentrations in stream bottom substrates, and it can reduce the quality and quantity of habitats for aquatic organisms. TSS can also pose a threat to recreational uses because of murky conditions and muddy stream bottoms. High levels of TSS in irrigation waters can clog irrigation ditches and drainage pumps.

Erosion and overland flow contribute some natural TSS to most streams. In watersheds with highly erodible soils and steep slopes, natural TSS concentrations can be very high. Excess TSS in overland flow can occur when poor land use and land cover practices are in place. This potentially includes grazing, row crops, construction activities, road runoff, and mining. Grazing and other practices that can degrade stream channels are other possible sources of TSS.

3.2.7 Other Inorganics (Sulfate)

Sulfur is found in the rocks and soils of southeastern Montana. Sulfur compounds from the rocks and soils form sulfate ions (SO_4^{-2}) when dissolved in water. Sulfate concentrations are measured in the lab and are typically reported in milligrams per liter. Sulfate is one of the many components measured by salinity and TDS. Therefore any increases or decreases in the sulfate concentrations of a waterbody will also cause changes in the salinity and TDS.

Sulfates are one portion of the salinity of water, and the salinity of a waterbody is important to many aquatic organisms because it regulates the flow of water into an out of an organism's cells (osmosis). In Rosebud Creek, it is likely that many native aquatic organisms have adapted to the natural moderate chloride concentrations. The effects of sulfates on non-native species (such as northern pike and rainbow trout) are unknown. Irrigation water with high sulfate concentrations can adversely affect crop production depending on the amount of water applied and the salt tolerance of the crop. High concentrations of sulfate in water produce unpleasant odors and can have adverse health effects (laxative effect) on humans and livestock.

Natural sources, such as geology and soils, contribute to the sulfate concentrations of a stream. There are also several potential anthropogenic sources of sulfates. Potential anthropogenic sources of sulfates are irrigation returns, oil and gas returns (e.g., CBM wells, oil wells), and agricultural runoff.

3.3 Applicable Water Quality Standards

The Rosebud Creek watershed is regulated by three jurisdictional entities that could have applicable water quality standards including the State of Montana, the Northern Cheyenne Tribe, and the Crow Tribe. The Crow Tribe does not, at this time, have approved or adopted water quality standards. As necessary, EPA and the Crow Tribe would use established EPA water quality criteria for any regulatory decisions (e.g., permit discharge limits). The Northern Cheyenne Tribe has adopted water quality standards, however, these standards are currently pending review by the USEPA. Currently, the only water quality standards applicable to the waters within the Rosebud Creek TPA are those promulgated by the State of Montana. Relative to salinity, the only approved and applicable water quality standards are narrative in form as promulgated by Administrative Rules of Montana Section 17.30.637.

The State of Montana is currently in the process of developing and adopting numeric criteria for EC and SAR to address salinity related issues potentially associated with future CBM discharges. As mentioned above, the Northern Cheyenne Tribal water quality standards for salinity are still pending review by the USEPA.

This section presents the current applicable water quality standards. It also presents the most up to date proposals regarding numeric criteria (as of the time that this report was prepared) including a status report regarding the proposed schedule for, and status of, their adoption.

The uncertainty regarding the timing of review and adoption of both Montana's and the Northern Cheyenne Tribe's water quality standards is acknowledged herein. It is also acknowledged that the standards presented in this section may change. These standards are presented to provide the best indication of water quality metrics available at this time with which to use as a basis for making water quality impairment determinations. All of the proposed standards are within the same relative range of values for protecting agricultural uses and are therefore considered appropriate for an initial screening of impairment. The final TMDL will be updated as appropriate to reflect the water quality standards that apply at that time.

3.3.1 Montana Standards

All waters in the Rosebud Creek watershed are assigned a C-3 use classification (ARM, 2002). The C-3 classification is described below. Waters classified as C-3 support non-salmonid fish species, and only marginally support drinking, agricultural, and industrial water supplies.

- C-3: Waters classified C-3 are to be maintained suitable for bathing, swimming and recreation, and growth and propagation of non-salmonid fishes and associated aquatic life, waterfowl and furbearers. The quality of these waters is naturally marginal for drinking, culinary and food processing purposes, agriculture and industrial water supply. Degradation which will impact established beneficial uses will not be allowed.

3.3.1.1 Narrative Standards

Montana narrative standards address two basic concepts (1) activities that would result in nuisance aquatic life are prohibited, and (2) no increases are allowed over naturally occurring conditions of sediment, settleable solids, oils, or floating solids, which are harmful to public health, recreation, safety, welfare, livestock, wild animals, birds, fish, and other wildlife (ARM, 2002). A summary of the narrative standards that apply to pollutants of concern in the Rosebud Creek TPA is shown in Table 3-3 and the full text is included in Appendix C. Aquatic life in the Rosebud Creek TPA is protected by several different narrative standards that apply to all of the pollutants of concern. Aquatic life may not be harmed by any anthropogenic source of pollution (ARM 17.30.637(d)), and conditions that produce undesirable aquatic life are prohibited (ARM 17.30.637(e)). Agricultural uses are protected by ARM 17.30.637(d), which states that no anthropogenic source of pollution may create conditions that are harmful to plant or animal life. All of the beneficial uses of a waterbody, whether a direct narrative standard exists or not, must be protected.

Table 3-3. Summary of the Montana narrative water quality standards and affected pollutants.

Rule	Text	Affected Pollutants
ARM 17.30.637	No wastes may be discharged and no activities conducted such that the wastes or activities, either alone or in combination with other wastes or activities, will violate, or can reasonably be expected to violate, any of the standards.	All Parameters
ARM 17.30.637(d)	State surface waters must be free from substances attributable to municipal, industrial, agricultural practices or other discharges that will create concentrations or combinations of materials which are toxic or harmful to human, animal, plant or aquatic life.	All Parameters
ARM 17.30.637(e)	State surface waters must be free from substances attributable to municipal, industrial, agricultural practices or other discharges that will create conditions which produce undesirable aquatic life.	All Parameters
ARM 17.30.624; 17.30.625; 17.30.629	The maximum allowable increase above naturally occurring turbidity is 10 nephelometric turbidity units except as permitted in ARM 17.30.637.	Total Suspended Solids
ARM 17.30.624; 17.30.625; 17.30.629	No increases are allowed above naturally occurring concentrations of sediment, settleable solids, oils, or floating solids which will or are likely to create a nuisance or render the waters harmful, detrimental, or injurious to public health, recreation, safety, welfare, livestock, wild animals, birds, fish, or other wildlife.	Total Suspended Solids

3.3.1.2 Numeric Standards

Numeric surface water quality standards have been developed for the protection of beneficial uses. Montana currently has three sets of standards: (1) standards that vary by beneficial use, (2) standards that apply to all surface waters of the state, and (3) standards that apply to specific waters in the state. Numeric standards for all Montana surface waters are summarized in the Montana Department of Environmental Quality (MDEQ) Circular WQB-7 (MDEQ, 2002b). The circular contains standards for numerous parameters for the protection of aquatic life and human health. All numeric standards that apply to impaired waters in the Rosebud Creek watershed are summarized in Tables 3-4 and 3-5.

REVISED NUMERIC CRITERIA

On August 29, 2002, the Montana Board of Environmental Review proposed numeric water quality standards for the Tongue River, Powder River, Little Powder River, Rosebud Creek and their tributaries for electrical conductivity (EC) and sodium adsorption ratio (SAR). All available water quality data are compared to these proposed standards in the main text of this document. On December 6, 2002, the Montana Board of Environmental Review instructed DEQ to prepare a supplemental notice of rulemaking regarding the adoption of numeric water quality standards for the Tongue River, Powder River, Little Powder River, Rosebud Creek and their tributaries for EC and SAR. This supplemental notice included a revised set of numeric criteria for EC and SAR. Insufficient time was available to modify this document to include consideration of these revised criteria. DEQ's new standards proposal is presented in Appendix D. A preliminary comparison of the revised numeric criteria to available water quality data for the Rosebud Creek watershed is presented in Appendix E. The forthcoming final TMDL document will be based on consideration of the approved and adopted water quality standards (for all appropriate jurisdictions) available at that time.

The metals standards for Montana are for total recoverable (TR) metals in a waterbody. In some cases, dissolved metals data were collected for Rosebud Creek. These data were compared to the Montana standards by converting the TR metals standards to dissolved standards using conversion factors developed by EPA (USEPA, 1996b). The conversion factors and the calculated dissolved standards are shown in Appendix F.

Montana has proposed standards for salinity (measured as EC at 25 degrees Celsius) and SAR (see text box) (MDEQ, 2002c, 2002d). Table 3-6 provides a summary of EC standards for the Rosebud Creek watershed. These are the draft salinity standards proposed by MDEQ on August 29, 2002. The proposed

SAR standard (August 29, 2002) varies depending on the salinity of the water. Under the proposed standards, the instantaneous SAR in a waterbody may not exceed the value given by the equation [(EC*0.0071) – 2.475]. At an EC of 350 µS/cm or less, the formula indicates that the allowable SAR is less than zero. Because of this nonsensical result, the formula does not apply when the EC is 350 µS/cm or less. When the formula given above for calculating the proposed SAR standard results in a value greater than 5, the SAR standard is 5. The proposed formula and conditions for SAR apply year-round to all waters in the Rosebud Creek watershed. This is a draft SAR standard proposed by MDEQ at the time of this report. SAR standards might change in the future (see text box above). Montana water quality standards do not include numeric criteria for suspended solids, nutrients, or other inorganics.

Table 3-4. Montana surface water quality standards for all waters in the state.

Parameter	Aquatic Life (acute) (µg/L)[2]	Aquatic Life (chronic) (µg/L)[3]	Human Health (µg/L)[2]
Aluminum (dissolved), (pH 6.5-9.0 only)	750	87	—
Arsenic (TR)	340	150	18
Barium (TR)	—	—	2,000
Cadmium (TR)	1.05 @ 50 mg/L hardness[1]	0.16 @ 50 mg/L hardness[1]	5
Chromium (III) (TR)	1,804 @ 100 mg/L hardness[1]	86 @ 100 mg/L hardness[1]	—
Copper (TR)	7.3 @ 50 mg/L hardness[1]	5.2 @ 50 mg/L hardness[1]	1,300
Iron (TR)	—	1,000	—
Lead (TR)	82 @ 100 mg/L hardness[1]	3.2 @ 100 mg/L hardness[1]	15
Nickel (TR)	261 @ 50 mg/L hardness[1]	29 @ 50 mg/L hardness[1]	100
Selenium (TR)	20	5	50
Silver (TR)	4.1 @ 100 mg/L hardness[1]	—	100
Zinc (TR)	67 @ 50 mg/L hardness[1]	67 @ 50 mg/L hardness[1]	2,000
Turbidity	The maximum allowable increase of turbidity over natural conditions is 10 NTU.		

[1]Standard is dependent on the hardness of the water, measured as the concentration of $CaCO_3$ (mg/L) (see Appendix F for the coefficients to calculate standard).
[2]Maximum allowable concentration.
[3]No four-day (96-hour) or longer period average concentration shall exceed these values.
TR – Total Recoverable.

Table 3-5. Aquatic life standards for DO (mg/L).

Time Period	Use Class C-3	
	Early Life Stages	Other Life Stages
30-day average	NA	5.5
7-day average	6.0	NA
7-day average minimum	NA	4.0
1-day minimum	5.0	3.0

[1]These are water column concentrations recommended to achieve the required inter-gravel DO concentrations shown in parentheses. For species that have early life stages exposed directly to the water column, the figures in parentheses apply.

Table 3-6. Montana DEQ proposed EC (µS/cm) standards for agricultural uses.

Waterbody	April 1–October 31 (Growing Season)	November 1– March 31 (Non-growing Season)
Rosebud Creek	1,000	2,000
Rosebud Creek Tributaries	500	2,000

3.3.1.3 Petitioner Standards

Several different agencies in the Tongue River, Powder River, and Rosebud Creek watersheds have petitioned the Montana Board of Environmental Review to establish SAR and salinity standards. The agencies are the Tongue River Water Users (TRWU), Tongue and Yellowstone Irrigation District (T&Y), Buffalo Rapids Irrigation District (Buffalo Rapids), and Northern Plains Resource Council (Northern Plains). These four groups are collectively referred to as the Petitioners. Standards have been proposed for the Powder River, Tongue River, and Rosebud Creek (TRWU et al., 2002). Proposed standards are maximum values that are not to be exceeded. Values are shown in Table 3-7. At the time of this report, these standards were presented to the Montana Board of Environmental Review, and they are part of the formal rulemaking process to develop salinity and SAR standards for the Rosebud Creek TPA. They are not to be interpreted as additional or enforceable standards for the watershed, and are simply presented here to illustrate the range of standards currently being considered.

Table 3-7. Petitioner proposed EC and SAR standards.

	EC (µS/cm)	SAR
Rosebud Creek at Kirby	700	1.0
Rosebud Creek at Colstrip	1,300	1.5
Rosebud Creek at the confluence with the Yellowstone River	1,700	3.0

3.3.1.4 Use Support Guidelines

Montana has use support guidelines to determine use impairments based on various sampling parameters. The aquatic life and fisheries use support guidelines for chemistry data consist of narrative and numeric criteria to determine use impairments (MDEQ, 2002a). The guidelines for determining the degree of aquatic life use impairment using chemistry data (nutrients, DO, suspended solids, and temperature) are shown below.

> *Unimpaired* – Water quality standards are not exceeded for any pollutant; or the measurements are similar to reference conditions; and/or for one parameter only, the water quality standard is randomly exceeded by no more than 10 percent of the samples in a large dataset.
>
> *Moderately Impaired* – Water quality standards are exceeded by less than or equal to 50 percent (parameters that do not have numeric values will be compared to reference conditions), or the water quality standards are exceeded by 11 to 25 percent of the samples from a large dataset.
>
> *Severely Impaired* – Water quality standards are exceeded by more than 50 percent (parameters that do not have numeric values will be compared to reference conditions), or the water quality standards are exceeded by more than 25 percent of the measurements from a large dataset.

The guidelines for determining the degree of aquatic life use impairment because of metals include specifications for addressing acute and chronic criteria. The metals guidelines are shown below.

> *Unimpaired* – No exceedance of acute or chronic standards, and/or the chronic standards are exceeded by less than 10 percent no more than once for one parameter in a three-year period when measurements were taken at least four times/year (quarterly).
>
> *Moderately Impaired* – Acute standards are exceeded by less than 25 percent; and/or chronic standards are exceeded by 10-50 percent; and/or water quality standards are exceeded in no more than 10 percent of the measurements from a large data set.
>
> *Severely Impaired* – Acute standards are exceeded by at least 25 percent; and/or chronic standards are exceeded by more than 50 percent; and/or water quality standards are exceeded in more than 10 percent of the measurements from a large data set.
>
> *Chronic Criteria Note* – When possible, use the average concentration of samples collected over a 96-hour period and compare directly to chronic standard values; one data point (n=1) is sufficient if no other data were collected within 96 hours.

Use support guidelines also suggest that waterbodies should be compared to reference conditions where available. MDEQ states that reference conditions may be determined through a combination of the following:

- Comparison of the waterbody to a less impaired stream
- Historical data showing the previous condition of the waterbody
- Conditions in a less-impaired upstream or downstream segment of the same waterbody
- Conditions in a paired watershed
- A review of pertinent literature or expert opinion
- Modeling

Streams are not impaired when they are determined to be similar to reference conditions. They are moderately impaired when moderately different from reference conditions, and they are severely impaired when severely different from reference conditions. This narrative comparison is used to determine agricultural impairments due to salinity and SAR, as well as aquatic life impairments due to chemical parameters, habitat modification, and siltation.

3.3.2 Northern Cheyenne Standards

Based on the tribally adopted water quality standards (currently pending review by USEPA), Rosebud Creek is beneficial use Class 1 cold water stream from the southern border of the Northern Cheyenne Reservation to Corral Creek (NCEPD, 2002). The segment from Corral Creek to the northern Reservation border is assigned a Class 1 cool water classification. Class 1 cold water streams "provide for protection, propagation, and growth of salmonid fishes, as well as protection, growth, and propagation of associated aquatic life normally found where summer water temperatures do not often exceed 20 degrees Celsius." Class 1 cool water streams "provide for protection, propagation, and growth of cool water fishes, as well as protection, growth, and propagation of associated aquatic life normally found where summer water temperatures do not often exceed 25 degrees Celsius." The main stem of Rosebud Creek was not assigned industrial, recreational, agricultural, wildlife, or drinking water uses by the Northern Cheyenne Tribe.

The Northern Cheyenne Tribe's narrative standards are similar to Montana's standards and address two basic concepts: (1) activities that would result in nuisance aquatic life are prohibited; and (2) no increases are allowed over naturally occurring conditions of sediment, settleable solids, oils, or floating solids, which are harmful to public health, recreation, safety, welfare, livestock, wild animals, birds, fish, or other wildlife.

Numeric standards for the Rosebud Creek watershed are shown in Tables 3-8 and 3-9. The salinity (EC and TDS) standards are similar to the proposed Montana standards, but the SAR standards for Rosebud Creek and its tributaries are more stringent.

Table 3-8. Northern Cheyenne surface water quality standards.

Parameter	Aquatic Life (acute) (µg/L)[2]	Aquatic Life (chronic) (µg/L)	Human Health (µg/L)[2]
Aluminum (TR), (pH 6.5-9.0 only)	750	87	
Arsenic	340	150	18
Barium			1,000
Cadmium	2.0	0.025	
Chloride	860,000	230,000	
Chromium (III)	570	74	
Copper	13	9.0	1,300
Iron		1,000	300
Lead	65	2.5	
Nickel	470	52	610
Selenium		5.0	170
Silver	3.4	0.12	
Zinc	120	120	9,100

[1]Standard is dependant on the hardness of the water, measured as the concentration of $CaCO_3$ (mg/L). Values are shown at 100 mg/L hardness (see Appendix F for the coefficients to calculate standard).
[2]Maximum allowable concentration.
TR – Total Recoverable.

Table 3-9. Numeric standards for EC, TDS, and SAR for waters in the Northern Cheyenne Reservation.

	EC (µS/cm)	SAR	TDS (mg/L)
Southern Boundary			
Irrigation Period Average[a]	1,000	—	660
Year Round Maximum	2,000	2.0	1,320
Northern Boundary			
Irrigation Period Average[a]	1,500	—	990
Year Round Maximum	2,000	3.0	1,320
Tributaries			
Irrigation Period Average[a]	1,500	3.0	990
Year Round Maximum	2,000	3.0	1,320

[a]Irrigation period average is the 30-day average applicable during the period of active irrigation or water spreading, defined by the Tribe as April 1st to November 15th, annually.
[b]Maximum values not to be exceeded.
Source: TRWU et al., 2002.

3.4 Rosebud Creek Water Quality Impairment Status

This section presents separate summaries and evaluations of all available water quality data for waters appearing on the Montana 1996 303(d) list. A preliminary analysis of the current beneficial use impairment status is also provided. In the absence of current, approved numeric water quality criteria, this section relies on the State's proposed numeric criteria, the Northern Cheyenne Tribe's adopted criteria discussed in Section 3.3.2, or appropriate surrogate targets where applicable. Water quality impairments were determined using the standards and data available at the time this report was written. Causes of impairment from the Montana 1996 303(d) list are analyzed. Also, each segment of Rosebud Creek was evaluated for impairments due to salinity, TDS, chlorides, and SAR. A summary of the current impairment status is presented in Table 3-10. In general, impairment decisions cannot be made at this time due to a lack of numeric targets or insufficient data. Final water quality impairment determinations will be made in the future as described in Section 1.3, including the determination of whether a TMDL is required for each parameter. Supporting documentation is provided on a water body by water body basis in the remainder of this section. Although data for waters within Northern Cheyenne lands are included within this analysis, where available, this document does not evaluate impairment conditions for those waters because applicable water quality standards have not yet been approved by EPA. Furthermore, development of TMDLs for any impaired waters on tribal lands will not be the responsibility of DEQ but rather the Northern Cheyenne Tribe and EPA.

Water chemistry data presented in the following sections were downloaded from the USGS National Water Information System (NWIS) database and from MDEQ's STOREASE database. USGS quality assurance/quality control standards (QA/QC) for data contained in the NWIS database are summarized on the NWIS web site at http://waterdata.usgs.gov/nwis/qwdata?help. These include protocols for sampling and analysis, as well as standards for data input and parameter codes. QA/QC standards for the STOREASE database are available from MDEQ's division of Planning, Prevention, and Assistance.

Additional water chemistry data for the Rosebud Creek watershed were obtained from the Northern Cheyenne Tribe and the TRWU. All of the available data were input into a Microsoft Access database to allow for storage and retrieval on a site specific or watershed basis. Additional reports, such as macroinvertebrate and periphyton studies, NRCS, FWS, and other miscellaneous studies, were used to help determine water quality impairments. These reports are summarized and documented in the following sections where they are applicable.

Table 3-10. Water quality impairment status summary.

Segment	Evaluated Cause of Impairment	1996 303(d) List	2002 303(d) List[a]	TMDL Requirement
Rosebud Creek - from the mouth 3.8 miles upstream to an irrigation dam (Lower Rosebud Creek)	Bank erosion		✔	No
	Chlorides	✔		No
	Flow alteration	✔		No
	Metals	✔		Yes
	Nutrients	✔		Undetermined
	Other habitat alterations		✔	No
	Other Inorganics	✔		Undetermined
	Salinity	✔		Undetermined
	SAR			Undetermined
	Suspended Solids	✔		Undetermined
	TDS	✔		Undetermined
Rosebud Creek - from the Northern Cheyenne Reservation boundary to the irrigation dam (Middle Rosebud Creek)	Chlorides	✔		Undetermined
	Flow alteration	✔		No
	Metals	✔		Undetermined
	Nutrients	✔	✔	Undetermined
	Other habitat alterations		✔	Undetermined
	Other Inorganics	✔		Undetermined
	Salinity	✔		Undetermined
	SAR			Undetermined
	Suspended Solids	✔		Undetermined
	TDS	✔		Undetermined
Rosebud Creek – from the headwaters to the southern border of the Northern Cheyenne Reservation (Upper Rosebud Creek)	Chlorides			Undetermined
	Flow alteration			No
	Metals			Undetermined
	Nutrients			Undetermined
	Other Inorganics			Undetermined
	Salinity			Undetermined
	SAR			Undetermined
	Suspended Solids			Undetermined
	TDS			Undetermined

[a]Not all causes of impairment were evaluated for the 2002 303(d) list.
Source: MDEQ, 1996, 2002.

The sections below describe the available water quality data for Rosebud Creek. Data include water quality, macroinvertebrate, periphyton, and habitat analyses. The data were obtained from USGS, MDEQ, TRWU, and the Northern Cheyenne Tribe.

The Montana 1996 303(d) list reported that Rosebud Creek from the mouth to the Northern Cheyenne Reservation boundary was impaired because of flow alterations, metals, nutrients, other inorganics, salinity/TDS/chlorides, and suspended solids. Impairments due to other inorganics are believed to refer to sulfates. Aquatic life and fishery uses were impaired by these causes in 1996.

In 2002, using additional data and a new listing methodology, MDEQ identified Rosebud Creek from the mouth to an irrigation dam 3.8 miles upstream (lower Rosebud Creek) as impaired because of bank erosion and other habitat alterations. Aquatic life and fishery uses were impaired in this segment because of these causes. Rosebud Creek from the diversion dam to the Northern Cheyenne Reservation boundary (middle Rosebud Creek) was impaired because of nutrients and other habitat alterations in 2002. Fishery uses in this segment were impaired by these causes. Other uses, including industrial, agricultural, recreational, and drinking water uses were not assessed in these segments because of insufficient credible data. No information was provided on the 1996 or 2002 lists for the upper segment of Rosebud Creek (from the headwaters to the southern boundary of the Northern Cheyenne Reservation).

The discussion below provides a review of available data to evaluate the water quality impairment status.

3.4.1 Macroinvertebrates and Periphyton

Aquatic life uses were impaired in Rosebud Creek near the mouth. Periphyton sampling in 1999 indicated that aquatic life was moderately impaired because of organic loading and siltation (Bahls, 2000). High salinity concentrations were also a possible cause of impairment at this site. However, upstream sites in Rosebud Creek near Lame Dear and Colstrip were fully supporting aquatic life uses. Nuisance algae levels were noted in the middle segment of Rosebud Creek.

Macroinvertebrate sampling was performed at three sites in Rosebud Creek on September 20, 1999 (Bollman, 2000). The results from the sampling were compared to MDEQ's provisional reference criteria for Montana plains region streams. The scores from the biological metrics indicated that all three sites were partially supporting aquatic life uses. Mild to moderate impairment appeared to result from sediment deposition, warm water temperatures, and organic inputs. Bollman noted, however, that the scoring criteria for the ecoregion did not seem appropriate for Rosebud Creek, and that macroinvertebrates found during sampling may be representative of the natural stream conditions. A habitat survey performed at the time of sampling found that conditions at the lower Rosebud Creek site (site 0529-04) appeared to be impaired because of a poor riparian zone and sub-optimal channel flow (Figure 3-2). Sites 0596-06 and 1872-01 both had stable streambanks and minor accumulations of fine sediment. This is possibly an indication that water chemistry is the cause of the impairment at the two upstream sites, and not poor habitat conditions.

Station 0529-04 was also sampled in July 2001 (Bollman, 2002b). Habitat at the time of sampling was ranked as marginal because of severe sediment deposition and monotonous benthic substrates. No macroinvertebrate impairments were found at the time of sampling and the site fully supporting aquatic life uses. However, the taxonomic composition suggests that warm water and nutrient enrichment may be present.

3.4.2 Fish

The Montana 2002 303(d) list assessment record indicated that an irrigation dam in the middle segment of Rosebud Creek prevented several species of game fish from migrating upstream (MDEQ, 2002a). This dam was noted as a cause of impairment for fishery uses in the stream.

3.4.3 Water Chemistry Assessment

Water chemistry data for Rosebud Creek were analyzed at sixteen stations in Montana (Figure 3-2). The sections below describe the available water chemistry data for Rosebud Creek.

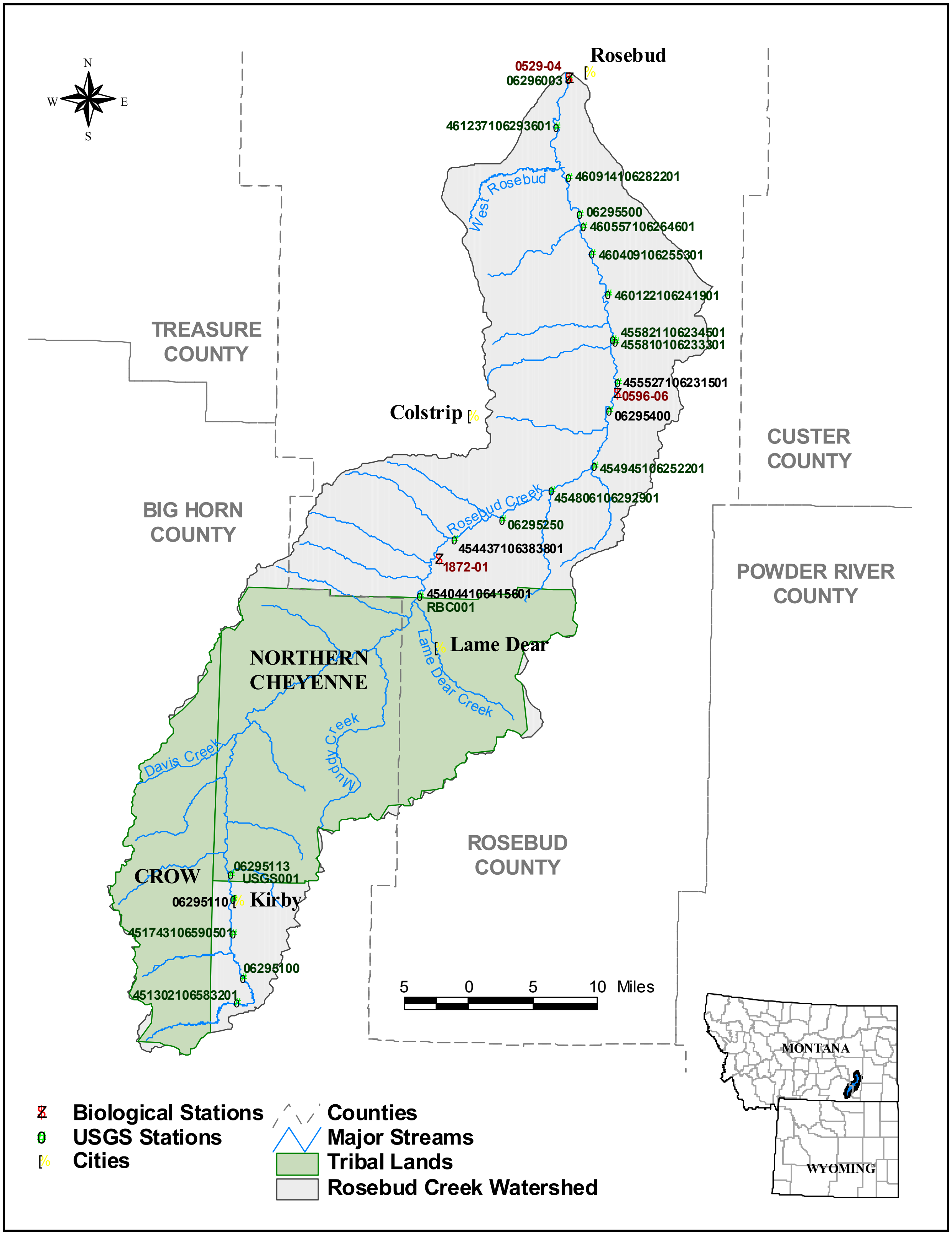

Figure 3-2. Rosebud Creek monitoring stations.

3.4.3.1 Salinity

Rosebud Creek was divided into four segments for the Montana 2002 303(d) list – lower Rosebud Creek, middle Rosebud Creek, upper Rosebud Creek, and Rosebud Creek Northern Cheyenne Reservation. As described in Section 3.4, two segments of Rosebud Creek (i.e., the lower and middle Rosebud Creek) were listed as impaired for salinity on the 1996 list. Agricultural uses in Rosebud Creek were not evaluated for the 2002 303(d) list, and salinity was not identified as a cause of impairment for any other beneficial uses. This section presents an updated evaluation of all segments of Rosebud Creek to verify the impairment status relative to salinity.

MDEQ has proposed salinity standards (measured as EC, at 25 °C) for rivers in the Rosebud Creek watershed. Separate standards were proposed for the main stem of Rosebud Creek and the Rosebud Creek tributaries. Separate standards have also been proposed for the growing season (April 1 through October 31) and the non-growing season (November 1 through March 31). The salinity standards are draft standards proposed at the time of this report. The standards might change in the future.

EC data are summarized in Tables 3-11 and 3-12 and are compared to proposed standards in Tables 3-13 through 3-15. Almost all average EC values during the growing season were greater than the 1,000 µS/cm criterion proposed by MDEQ. Figure 3-3 shows a plot of all the EC data for lower Rosebud Creek. The figure shows that there is little difference between growing season and non-growing season concentrations. There is a significant amount of variability in the data in the lower segment that is not present in the middle or upper segments of Rosebud Creek (Figures 3-4 and 3-5). This is most likely attributable to the irrigation dam and irrigation practices in lower Rosebud Creek. Also, there appears to be an increase in salinity concentrations in the lower segment of Rosebud Creek in 1981. Figure 3-6 shows that EC values generally increase from upstream to downstream and values fluctuate with flow (Figures 3-7 and 3-8). Higher EC values occur when there is little flow. There appears to be an increasing trend in EC values in lower Rosebud Creek.

A final water quality impairment determination will not be made for salinity (EC) until the Montana Board of Environmental Review makes their final decision regarding the adoption of numeric criteria (see Section 3.3.1.2).

Table 3-11. Summary of EC data, Rosebud Creek (µS/cm) (November 1–March 31).

Station	Count	Average	Min	Max	CV[a]	Min Date	Max Date
Lower							
6296003	113	1,727	190	3,770	47%	11/8/74	3/21/01
Middle							
454044106415601	1	1,170	1,170	1,170	NA	11/1/77	11/1/77
454806106292901	1	1,250	1,250	1,250	NA	11/1/77	11/1/77
455810106233301	1	1,340	1,340	1,340	NA	11/1/77	11/1/77
460557106264601	1	1,380	1,380	1,380	NA	11/2/77	11/2/77
460914106282201	1	1,340	1,340	1,340	NA	11/2/77	11/2/77
6295250	95	1,410	310	2,210	27%	11/7/74	3/21/01
6295400	16	1,368	400	1,860	25%	11/7/74	11/1/77
6295500	15	1,335	350	1,870	32%	11/8/74	3/23/77
Upper							
6295100	6	1,039	940	1,340	15%	12/13/82	3/7/88
6295110	8	914	802	1,000	7%	11/1/77	3/27/79
6295113	77	940	215	1,240	18%	12/10/79	3/27/01

[a]CV – Coefficient of Variation (standard deviation/mean).

Table 3-12. Summary of EC data, Rosebud Creek (µS/cm) (April 1–October 31).

Station	Count	Average	Min	Max	CV[a]	Min Date	Max Date
Lower							
6296003	188	1,828	410	3,630	37%	10/10/74	6/11/02
Middle							
454044106415601	4	1,480	1,130	1,840	25%	8/24/78	10/17/83
454437106383801	1	2,250	2,250	2,250	NA	10/17/83	10/17/83
454806106292901	2	3,330	3,260	3,400	3%	10/17/83	10/17/83
455527106231501	1	6,500	6,500	6,500	NA	10/18/83	10/18/83
460557106264601	4	3,173	1,380	5,100	65%	8/24/78	10/18/83
6295250	138	1,399	152	2,480	25%	10/9/74	6/19/01
6295400	23	1,393	900	3,300	45%	10/9/74	10/17/83
6295500	17	1,189	950	1,590	16%	10/10/74	5/25/77
Upper							
451302106583201	3	1,157	1,100	1,220	5%	10/31/77	10/16/83
451743106590501	1	1,080	1,080	1,080	NA	10/16/83	10/16/83
6295100	9	1,095	898	1,200	9%	4/19/83	6/9/88
6295110	13	871	657	955	10%	10/4/77	9/10/79
6295113	113	954	680	2,110	15%	10/1/79	8/29/01

[a]CV – Coefficient of Variation (standard deviation/mean).

Table 3-13. Summary of EC exceedances, lower Rosebud Creek.

Season	Criteria (µS/cm)	Total # of Samples	Total # of Exceedances	Percent Exceeding	Total # of Samples, 1996-2002	Total # of Exceedances, 1996-2002	Percent Exceeding, 1996-2002
MDEQ[a]							
Growing Season[b]	1,000	188	169	90%	31	29	94%
Non-growing Season	2,000	113	35	31%	12	6	50%
Petitioners (Rosebud Creek at the mouth)[a]							
Year Round	1,700	301	156	52%	43	31	72%

[a]Maximum value.
[b]Irrigation season is from April 1st to October 31st.

Table 3-14. Summary of EC exceedances, middle Rosebud Creek.

Season	Criteria (µS/cm)	Total # of Samples	Total # of Exceedances	Percent Exceeding	Total # of Samples, 1996-2002	Total # of Exceedances, 1996-2002	Percent Exceeding, 1996-2002
MDEQ[a]							
Growing Season[b]	1,000	190	168	88%	24	23	96%
Non-growing Season	2,000	131	3	2%	13	1	8%
Northern Cheyenne – Northern Border							
Irrigation period[c,d] (average)	1,500	203	57	28%	25	10	40%
Year Round Maximum	2,000	321	19	6%	37	2	5%
Petitioners (Rosebud Creek at the mouth)[a]							
Year Round	1,700	321	49	15%	37	7	19%

[a]Maximum value.
[b]Irrigation season is from April 1st to October 31st.
[c]Irrigation period average is the 30-day average applicable during the period of active irrigation or water spreading, defined by the Tribe as April 1st to November 15th, annually.
[d]Average values per month per year are evaluated for the purpose of this analysis.

Table 3-15. Summary of EC exceedances, upper Rosebud Creek.

Season	Criteria (µS/cm)	Total # of Samples	Total # of Exceedances	Percent Exceeding	Total # of Samples, 1996-2002	Total # of Exceedances, 1996-2002	Percent Exceeding, 1996-2002
MDEQ[a]							
Growing Season[b]	1,000	139	30	22%	18	2	11%
Non-growing Season	2,000	91	0	0%	9	0	0%
Northern Cheyenne – Southern Border							
Irrigation period[c,d] (average)	1,000	152	37	24%	18	2	11%
Year Round Maximum	2,000	220	1	0%	27	1	4%
Petitioners (Northern border of the Northern Cheyenne Reservation)[a]							
Year Round	1,300	220	3	1%	27	1	4%

[a]Maximum value.
[b]Irrigation season is from April 1st to October 31st.
[c]Irrigation period average is the 30-day average applicable during the period of active irrigation or water spreading, defined by the Tribe as April 1st to November 15th, annually.
[d]Average values per month per year are evaluated for the purpose of this analysis.

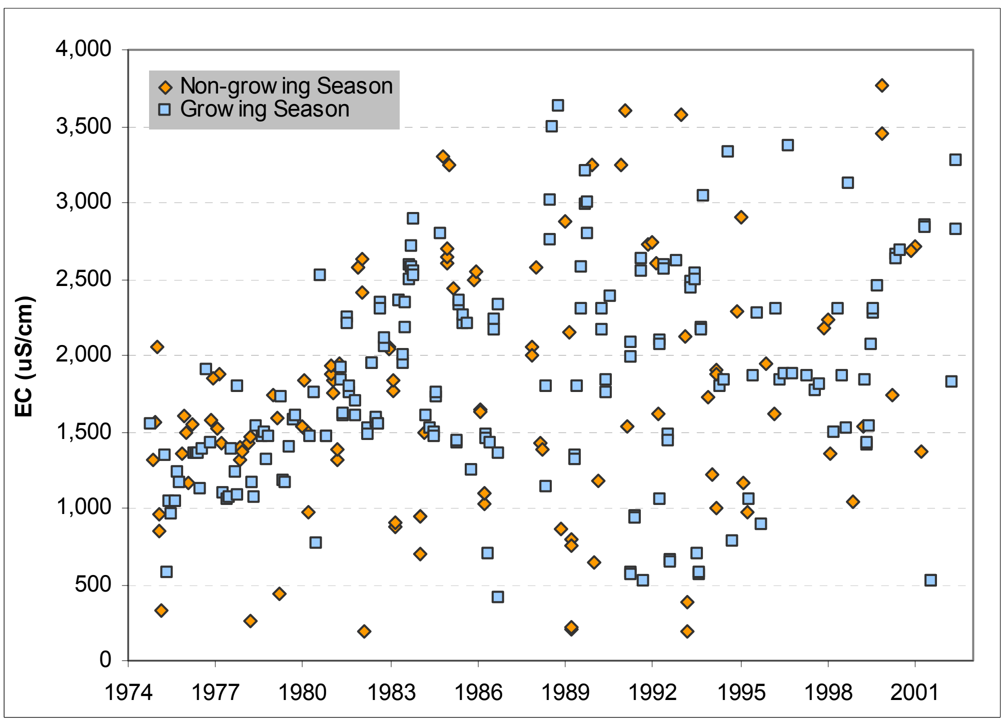

Figure 3-3. EC data for the lower Rosebud Creek (all stations).

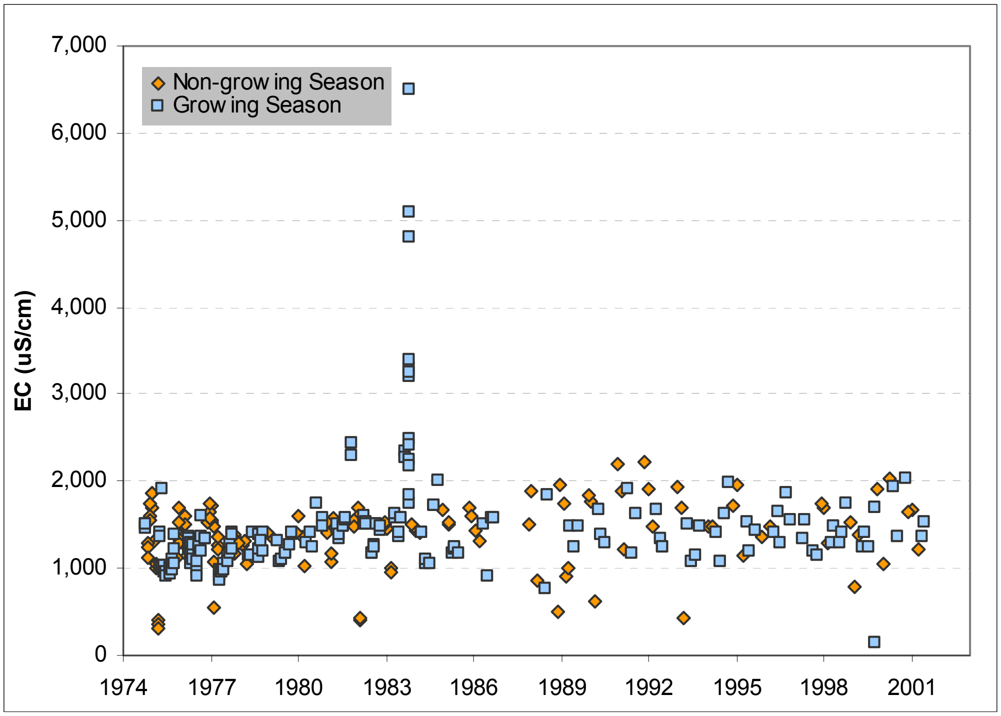

Figure 3-4. EC data for the middle Rosebud Creek (all stations).

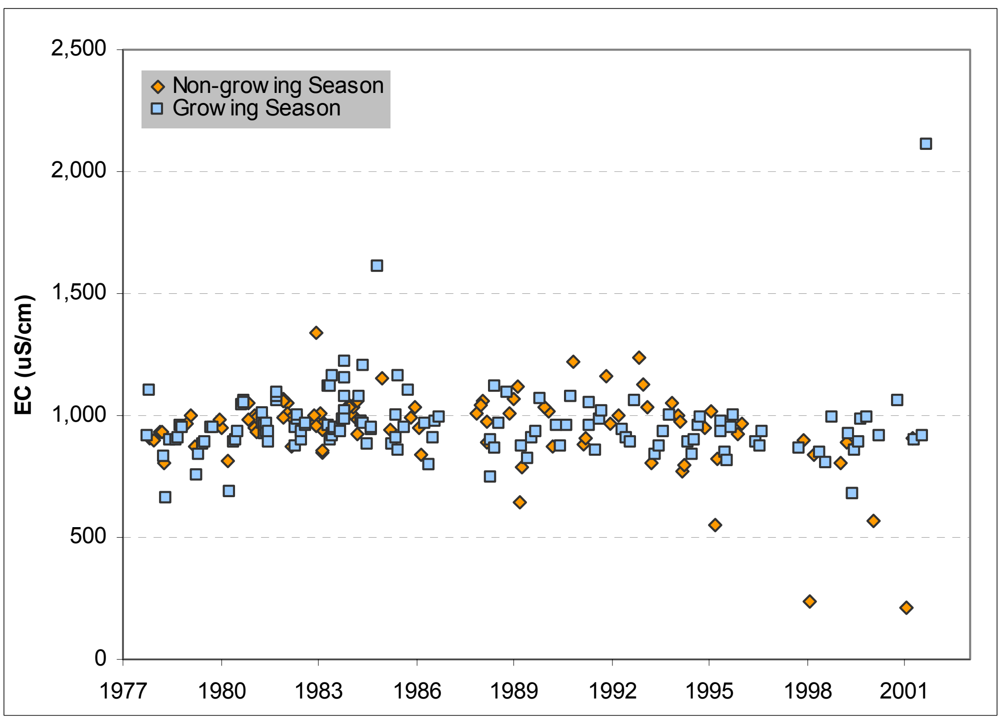

Figure 3-5. EC data for the upper Rosebud Creek (all stations).

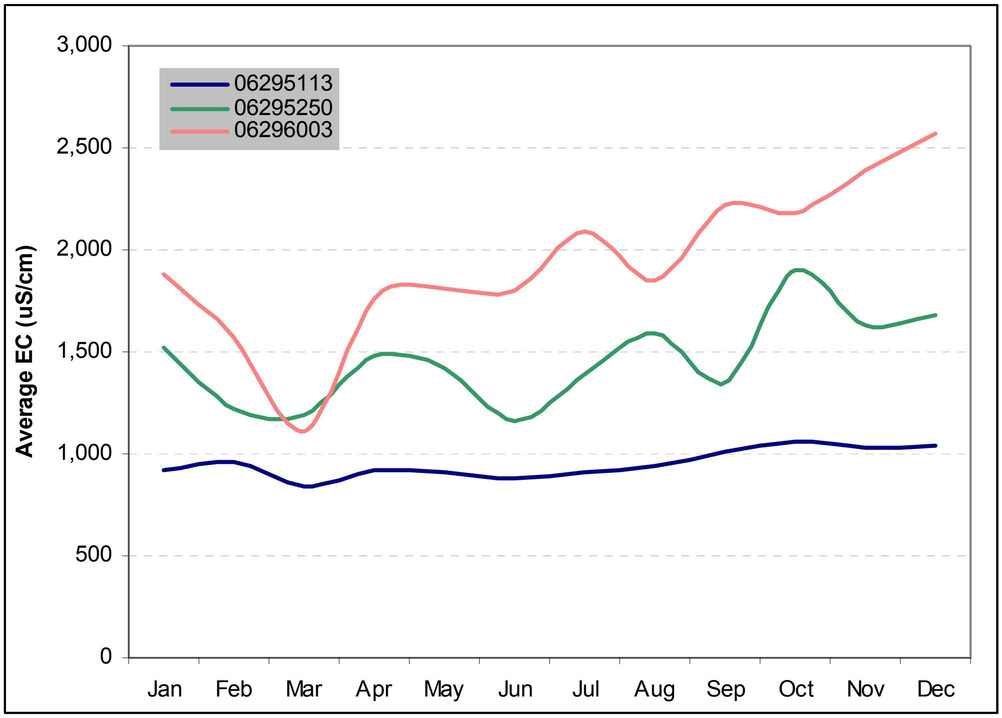

Figure 3-6. Average monthly EC at three USGS stations (1980-2000).

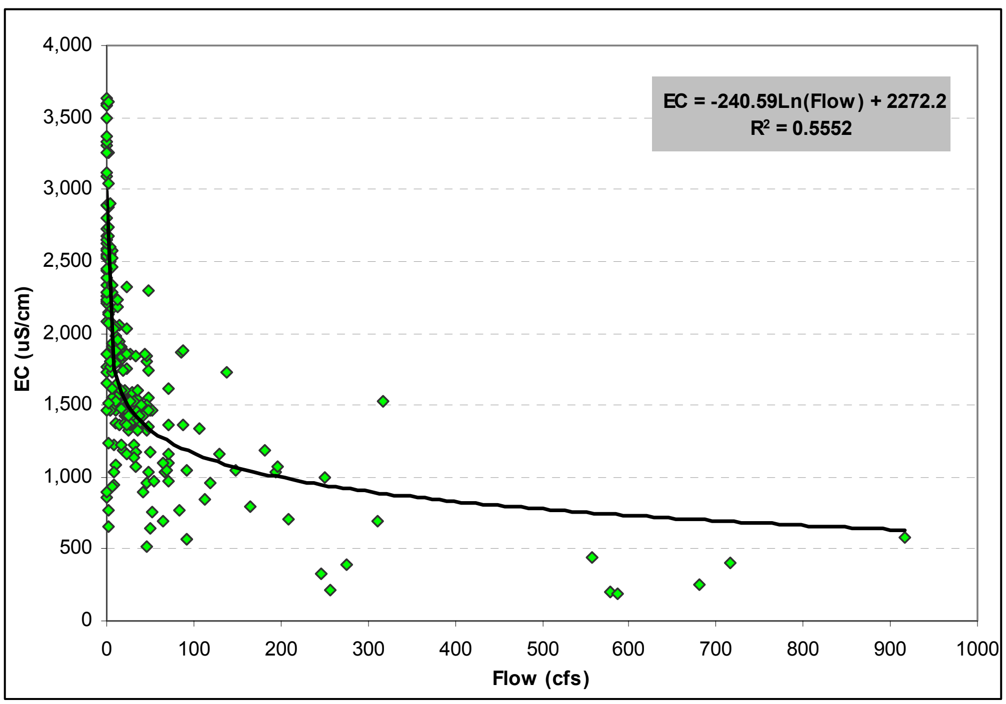

Figure 3-7. Relationship between EC and flow at station 06296003.

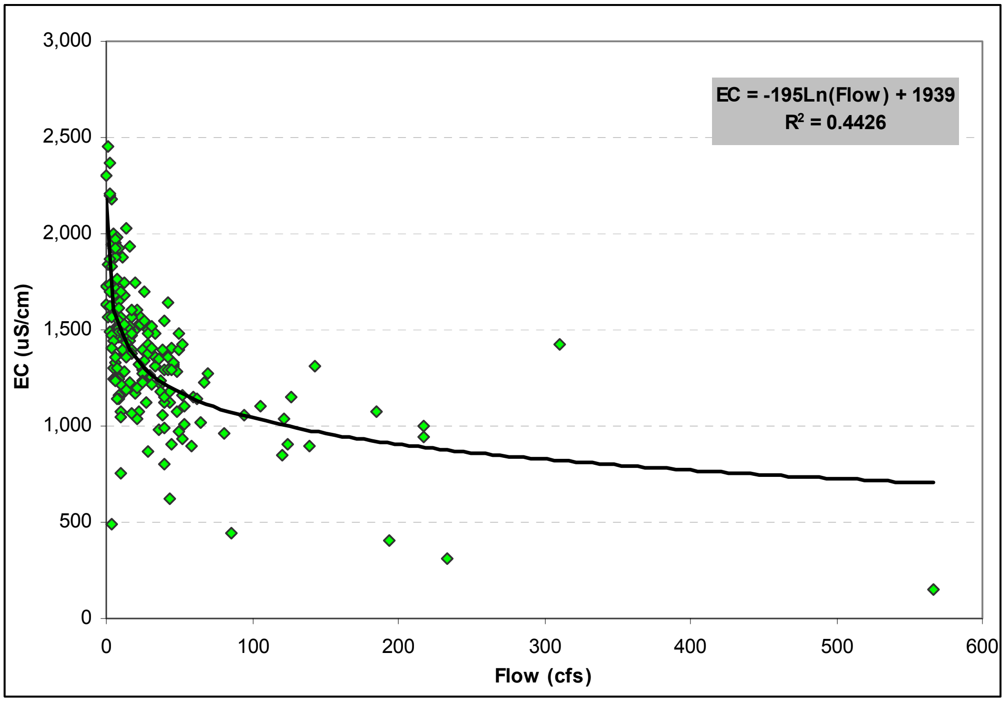

Figure 3-8. Relationship between EC and flow at station 06295250.

3.4.3.2 Total Dissolved Solids

Rosebud Creek was divided into four segments for the Montana 2002 303(d) list – lower Rosebud Creek, middle Rosebud Creek, upper Rosebud Creek, and Rosebud Creek Northern Cheyenne Reservation. As described in Section 3.4, two segments of Rosebud Creek (i.e., the lower and middle Rosebud Creek) were listed as impaired for total dissolved solids (TDS) on the 1996 list. Agricultural uses in Rosebud Creek were not evaluated for the 2002 303(d) list, and TDS was not identified as a cause of impairment for any other beneficial uses. This section presents an updated evaluation of all segments of Rosebud Creek to verify the impairment status relative to TDS.

Section 3.4.3.1 described salinity concentrations (measured as EC) in Rosebud Creek. EC is an indirect measurement of total dissolved solids. The relationship between TDS and EC is different for each waterbody, and varies with the type of ions in solution and temperature. Figures 3-9 through 3-11 show the relationships between EC and TDS in the lower, middle, and upper segments of Rosebud Creek. The graphs show EC and TDS data obtained on the same date and location, and confirms the strong relationship between EC and TDS. The relationship between the two parameters in lower Rosebud Creek is EC = 1.44(TDS). For the middle segment of Rosebud Creek, the relationship is EC = 1.50(TDS). The relationship for the upper segment of Rosebud Creek is EC = 1.58(TDS). Therefore in the lower Rosebud Creek, the proposed EC standard of 1,000 µS/cm during the growing season is equivalent to a TDS concentration of 694 mg/L, and an EC of 2,000 µS/cm is equivalent to 1,389 mg/L. At station 06296003, the major ions measured by TDS were on average sulfate (43%), sodium (13%), calcium (8%), chloride (1%), and magnesium (9%). A large portion of dissolved solids also appears to be bicarbonate ions. Table 3-16 shows the proposed EC standards and the calculated TDS targets for the all three segments of Rosebud Creek.

TDS data for the growing season and non-growing season are summarized in Tables 3-17 and 3-18. Average values during the growing season regularly exceeded calculated TDS targets in the lower and middle Rosebud Creek. Figure 3-12 shows the available TDS data for Rosebud Creek. There were few recent data, and the most recent sampling for the lower, middle, and upper segments occurred in 1982. There appeared to be an increase in TDS concentrations in the lower segment of Rosebud Creek in 1981, which coincides with the increase in EC described in Section 3.4.3.1.

A final water quality impairment determination will not be made for TDS until the Montana Board of Environmental Review makes their final decision regarding the adoption of numeric criteria for salinity (EC) (see Section 3.3.1.2). Also, a water quality impairment determination cannot be made for Rosebud Creek because there is a lack of current data. The most recent TDS data were collected in 1982.

Table 3-16. Proposed EC standards and calculated TDS targets.

Segment	Proposed EC Standard		Calculated TDS Target	
	Growing Season	Non-growing Season	Growing Season	Non-growing Season
Lower	1,000	2,000	694	1,389
Middle	1,000	2,000	667	1,333
Upper	1,000	2,000	633	1,266

Table 3-17. Summary of TDS data, Rosebud Creek (mg/L) (November 1–March 31).

Station	Count	Average	Min	Max	CV[a]	Min Date	Max Date
Lower							
6296003	36	969	112	1,880	41%	11/8/74	2/18/82
Middle							
454044106415601	2	799	790	807	2%	11/1/77	11/1/77
454806106292901	2	861	860	861	0%	11/1/77	11/1/77
455810106233301	2	896	862	929	5%	11/1/77	11/1/77
460557106264601	2	950	943	956	1%	11/2/77	11/2/77
460914106282201	2	923	907	938	2%	11/2/77	11/2/77
6295250	32	858	198	1,150	24%	11/7/74	2/17/82
6295400	17	866	214	1,040	22%	11/7/74	11/1/77
6295500	15	855	215	1,080	30%	11/8/74	3/23/77
Upper							
6295110	9	573	492	632	7%	11/1/77	3/27/79
6295113	10	622	551	672	7%	12/10/79	3/1/82

[a]CV – Coefficient of Variation (standard deviation/mean).

Table 3-18. Summary of TDS data, Rosebud Creek (mg/L) (April 1–October 31).

Station	Count	Average	Min	Max	CV[a]	Min Date	Max Date
Lower							
6296003	51	1,000	378	1,780	27%	10/10/74	9/15/82
Middle							
454044106415601	4	813	776	853	5%	8/24/78	10/25/78
460557106264601	4	985	975	992	1%	8/24/78	10/25/78
6295250	48	845	555	1,780	22%	10/9/74	9/15/82
6295400	21	809	588	1,150	16%	10/9/74	9/29/77
6295500	17	835	633	1,190	18%	10/10/74	5/25/77
Northern Cheyenne							
USGS001	2	540	530	550	3%	6/19/01	6/19/01
RBC001	2	885	880	890	7%	5/31/01	6/19/01
Upper							
451302106583201	2	690	676	703	3%	10/31/77	10/31/77
6295110	15	556	414	646	12%	10/4/77	9/10/79
6295113	17	596	408	685	11%	10/1/79	8/16/82

[a]CV – Coefficient of Variation (standard deviation/mean).

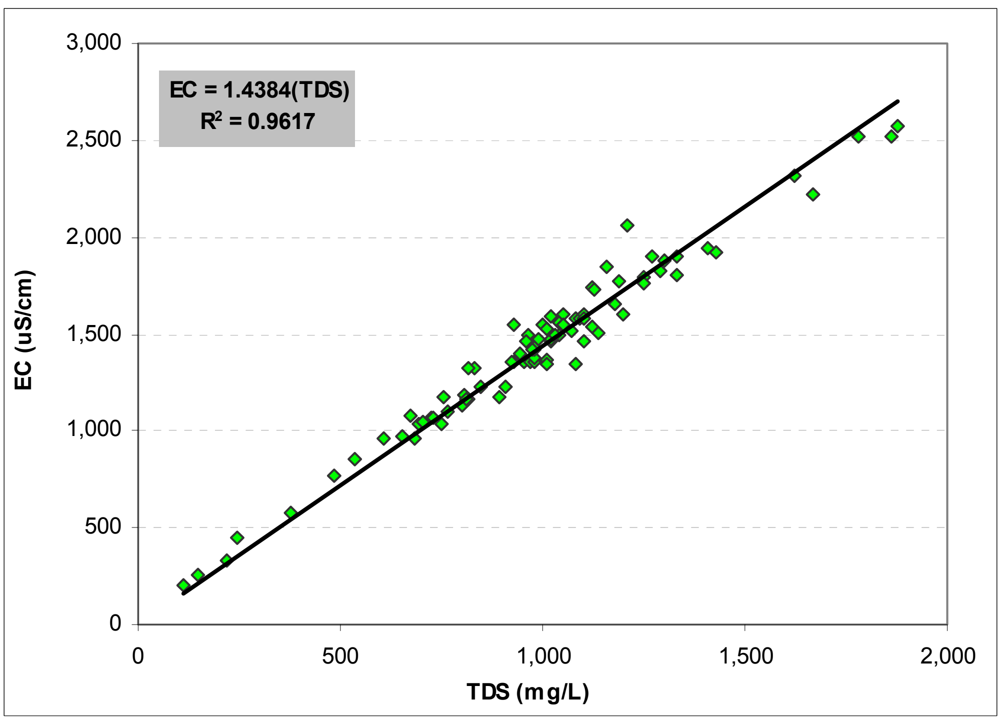

Figure 3-9. Relationship between EC and TDS in the lower Rosebud Creek.

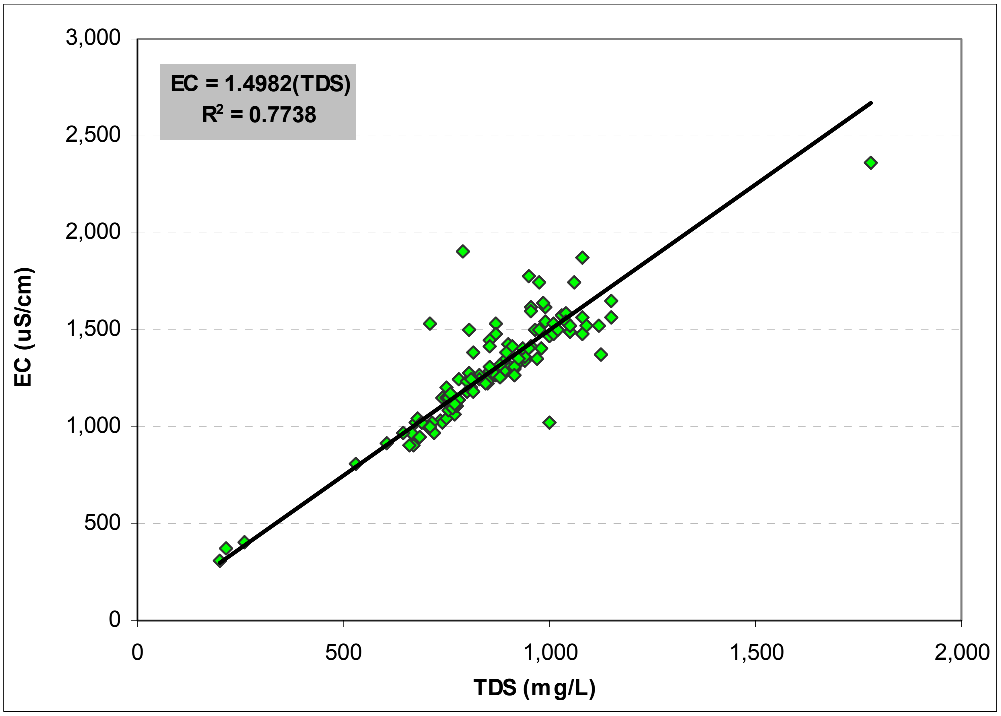

Figure 3-10. Relationship between EC and TDS in the middle Rosebud Creek.

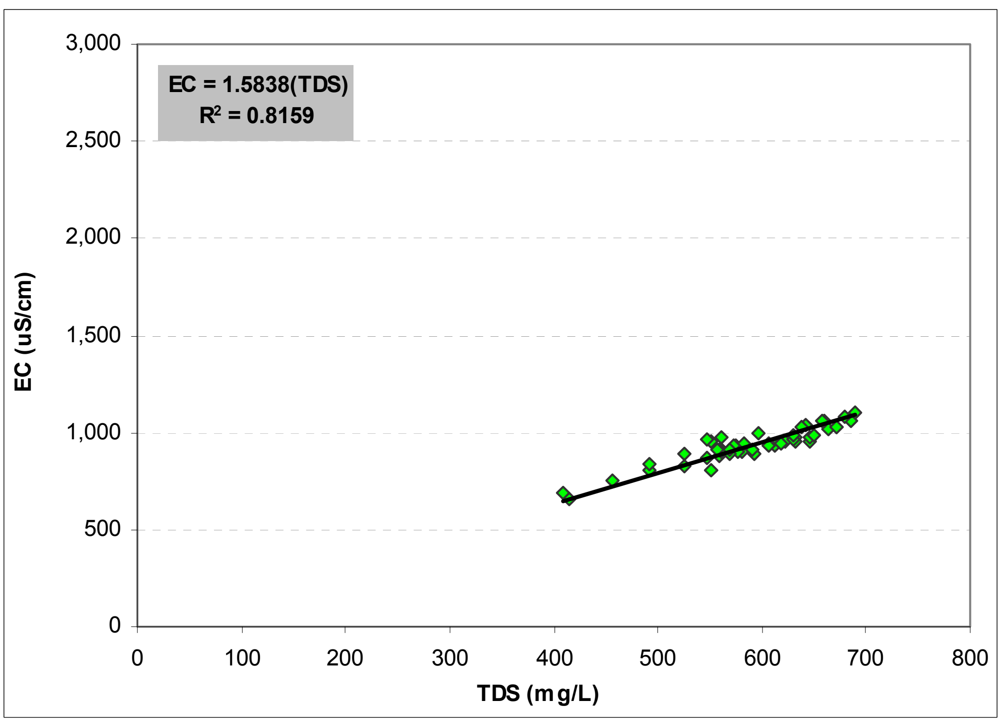

Figure 3-11. Relationship between EC and TDS in the upper Rosebud Creek.

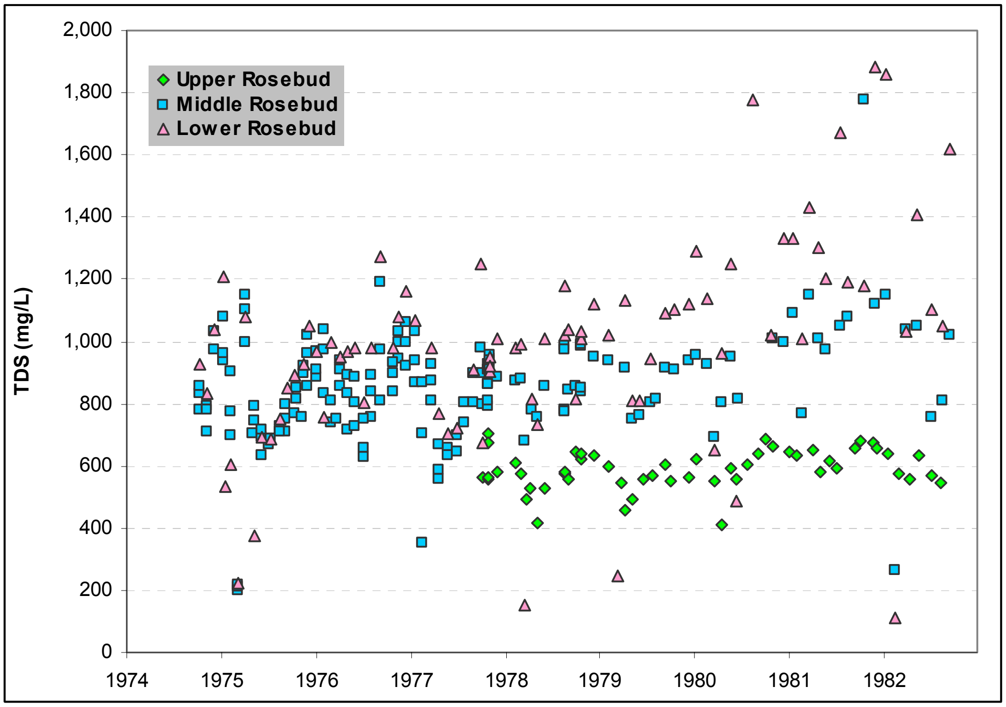

Figure 3-12. TDS data for Rosebud Creek.

3.4.3.3 Chlorides

Rosebud Creek was divided into four segments for the Montana 2002 303(d) list – lower Rosebud Creek, middle Rosebud Creek, upper Rosebud Creek, and Rosebud Creek Northern Cheyenne Reservation. As described in Section 3.4, two segments of Rosebud Creek (i.e., the lower and middle Rosebud Creek) were listed as impaired for chlorides on the 1996 list. Agricultural uses in Rosebud Creek were not evaluated for the 2002 303(d) list, and chlorides were not identified as a cause of impairment for any other beneficial uses. This section presents an updated evaluation of all segments of Rosebud Creek to verify the impairment status relative to chlorides.

USEPA recommended chloride standards for streams and rivers based on the aquatic toxicity of plant, fish, and invertebrate species (USEPA, 1999). USEPA recommends an acute standard of 860 mg/L and a chronic standard of 230 mg/L. These standards were adopted by the Northern Cheyenne Tribe. Montana does not have numeric standards for chlorides.

Chloride data in Rosebud Creek are summarized in Tables 3-19 and 3-20. Average concentrations were below the USEPA proposed standards. Chloride concentrations showed an increasing trend in lower Rosebud Creek (Figure 3-13). The average concentration from 1974 to 1980 was 6.1 and the average concentration from 1981 to 2000 was 12.3. There was also more variability in the data after 1980. There were few recent data in the middle and upper segments of Rosebud Creek.

Based on an analysis of available data, chlorides are not impairing agricultural or aquatic life uses in the lower segment of Rosebud Creek. Chloride concentrations for the lower segment of Rosebud Creek were much lower than the USEPA recommended standards to protect aquatic life uses. Concentrations were also much lower than the calculated TDS targets to protect agricultural uses (see Section 3.4.1.3.2). A final water quality determination for the middle and upper segments of Rosebud Creek could not be made because of a lack of current data. The most recent chlorides data were collected in 1985.

Table 3-19. Summary of chloride data, Rosebud Creek (mg/L) (November 1–March 31).

Station	Count	Average	Min	Max	CV[a]	Min Date	Max Date
Lower							
6296003	45	7.8	2.5	27.0	58%	11/8/74	11/5/99
Middle							
454044106415601	1	4.9	4.9	4.9	NA	11/1/77	11/1/77
454806106292901	1	5.2	5.2	5.2	NA	11/1/77	11/1/77
455810106233301	1	5.7	5.7	5.7	NA	11/1/77	11/1/77
460557106264601	1	6.2	6.2	6.2	NA	11/2/77	11/2/77
460914106282201	1	7.2	7.2	7.2	NA	11/2/77	11/2/77
6295250	37	5.8	1.1	10.0	23%	11/7/74	2/22/85
6295400	16	5.5	3.1	7.4	17%	11/7/74	11/1/77
6295500	15	5.5	2.7	7.4	25%	11/8/74	3/23/77
Upper							
6295110	8	3.6	2.8	4.2	12%	11/1/77	3/27/79
6295113	16	4.4	3.2	6.0	16%	12/10/79	3/21/84

[a]CV – Coefficient of Variation (standard deviation/mean).

Table 3-20. Summary of chloride data, Rosebud Creek (mg/L) (April 1–October 31).

Station	Count	Average	Min	Max	CV[a]	Min Date	Max Date
Lower							
6296003	86	9.8	2.2	28.1	59%	10/10/74	5/16/00
Middle							
454044106415601	3	8.2	4.8	14.0	62%	8/24/78	10/17/83
454806106292901	1	7.6	7.6	7.6	NA	10/17/83	10/17/83
460557106264601	3	13.9	6.1	29.0	94%	8/24/78	10/18/83
6295250	58	7.1	3.0	70.0	122%	10/9/74	5/14/85
6295400	22	5.9	3.3	20.0	63%	10/9/74	10/17/83
6295500	17	5.2	3.6	7.5	20%	10/10/74	5/25/77
Northern Cheyenne							
USGS001	2	2.1	2.0	2.1	3%	6/19/01	6/19/01
RBC001	2	5.6	4.9	6.2	17%	6/19/01	6/19/01
Upper							
451302106583201	2	3.8	3.5	4.1	11%	10/31/77	10/16/83
6295110	13	3.4	2.4	4.2	18%	10/4/77	9/10/79
6295113	25	8.2	2.1	88.0	209%	10/1/79	8/30/84

[a]CV – Coefficient of Variation (standard deviation/mean).

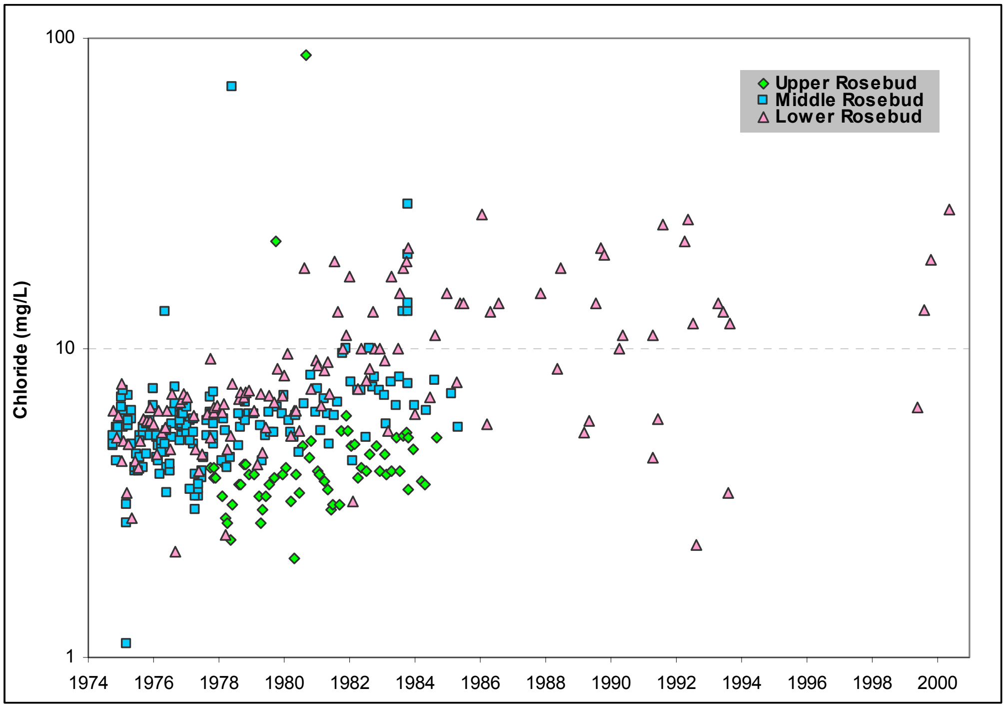

Figure 3-13. Chloride data for Rosebud Creek.

3.4.3.4 SAR

Rosebud Creek was divided into four segments for the Montana 2002 303(d) list – lower Rosebud Creek, middle Rosebud Creek, upper Rosebud Creek, and Rosebud Creek Northern Cheyenne Reservation. Rosebud Creek was not listed as impaired for SAR on the 1996 list. Agricultural uses in Rosebud Creek were not evaluated for the 2002 303(d) list, and SAR was not identified as a cause of impairment for any other beneficial uses. This section presents an updated evaluation of all segments of Rosebud Creek to verify the impairment status relative to SAR.

SAR data for Rosebud Creek are summarized in Table 3-21. Tables 3-22 through 3-24 compares the SAR data to the proposed SAR standards. There were few recent data. However, 88 percent of recent data in lower Rosebud Creek exceeded MDEQ's proposed criteria. Figure 3-14 shows that there was a significant increase in SAR in the lower segment of Rosebud Creek beginning in 1981. This is due to an increase in sodium concentrations in the river (Figure 3-15). The average sodium concentration more the doubled after 1981 (Table 3-25). Calcium and magnesium concentrations remained relatively constant throughout the entire time period. An increase in sodium with stable calcium and magnesium concentrations leads to an increase in SAR.

A final water quality impairment determination will not be made for SAR until the Montana Board of Environmental Review makes their final decision regarding the adoption of numeric criteria for SAR (see Section 3.3.1.2). Also, a water quality impairment determination cannot be made for the middle and upper segments of Rosebud Creek because there is a lack of recent data. The most recent SAR data were collected in 1985.

Table 3-21. Summary of SAR data, Rosebud Creek.

Station	Count	Average	Min	Max	CV[a]	Min Date	Max Date
Lower							
6296003	134	3.3	0.9	11.7	64%	10/10/74	6/11/02
Middle							
6295250	95	1.4	0.5	3.3	31%	10/9/74	5/14/85
6295400	38	1.4	0.5	4.0	36%	10/9/74	10/17/83
6295500	32	1.5	0.8	2.3	22%	10/10/74	5/25/77
454044106415601	4	1.5	1.1	2.4	41%	11/1/77	10/17/83
454806106292901	2	3.5	1.4	5.6	84%	11/1/77	10/17/83
455810106233301	1	0.7	0.7	0.7	NA	11/1/77	11/1/77
460557106264601	4	3.3	1.6	8.2	98%	11/2/77	10/18/83
460914106282201	1	1.7	1.7	1.7	NA	11/2/77	11/2/77
Northern Cheyenne							
RBC001	2	1.9	1.8	1.9	4%	6/19/01	6/19/01
USGS001	2	0.8	0.8	0.8	0%	6/19/01	6/19/01
Upper							
6295110	21	0.5	0.3	0.6	18%	10/4/77	9/10/79
6295113	41	0.6	0.4	0.8	15%	10/1/79	8/30/84
451302106583201	2	0.5	0.4	0.6	22%	10/31/77	10/16/83

[a]CV – Coefficient of Variation (standard deviation/mean).

Table 3-22. Summary of SAR exceedances, lower Rosebud Creek

Season	SAR Criteria	Total # of Samples	Total # of Exceedances	Percent Exceeding	Total # of Samples, 1996-2002	Total # of Exceedances, 1996-2002	Percent Exceeding, 1996-2002
MDEQ							
All Seasons	Variable[a]	134	37	28%	8	7	88%
Northern Cheyenne – Northern Border							
All Seasons	3.0	134	49	38%	8	7	88%
Petitioners (Rosebud Creek at the mouth)							
All Seasons	3.0	134	49	38%	8	7	88%

[a]Reported data are from sample dates with both a SAR and salinity measurement, and criteria are based on the formula (EC*0.0071) – 2.475.

Table 3-23. Summary of SAR exceedances, middle Rosebud Creek

Season	SAR Criteria	Total # of Samples	Total # of Exceedances	Percent Exceeding	Total # of Samples, 1996-2002	Total # of Exceedances, 1996-2002	Percent Exceeding, 1996-2002
MDEQ							
All Seasons	Variable[a]	177	3	2%	0	NA	NA
Northern Cheyenne – Northern Border							
All Seasons	3.0	177	5	3%	0	NA	NA
Petitioners (Rosebud Creek at the mouth)							
All Seasons	3.0	177	5	3%	0	NA	NA

[1]Reported data are from sample dates with both a SAR and salinity measurement, and criteria are based on the formula (EC*0.0071) – 2.475.

Table 3-24. Summary of SAR exceedances, upper Rosebud Creek

Season	SAR Criteria	Total # of Samples	Total # of Exceedances	Percent Exceeding	Total # of Samples, 1996-2002	Total # of Exceedances, 1996-2002	Percent Exceeding, 1996-2002
MDEQ							
All Seasons	Variable[a]	64	0	0%	0	NA	NA
Northern Cheyenne – Southern Border							
All Seasons	2.0	64	0	0%	0	NA	NA
Petitioners (Northern border of the Northern Cheyenne Reservation)							
All Seasons	1.5	64	0	0%	0	NA	NA

[1]Reported data are from sample dates with both a SAR and salinity measurement, and criteria are based on the formula (EC*0.0071) – 2.475.

Table 3-25. Average concentrations (mg/L) in the lower Rosebud Creek.

Time Period	Calcium	Magnesium	Sodium
1974-1980	72.3	89.5	107.5
1981-2001	68.5	102.2	236.5

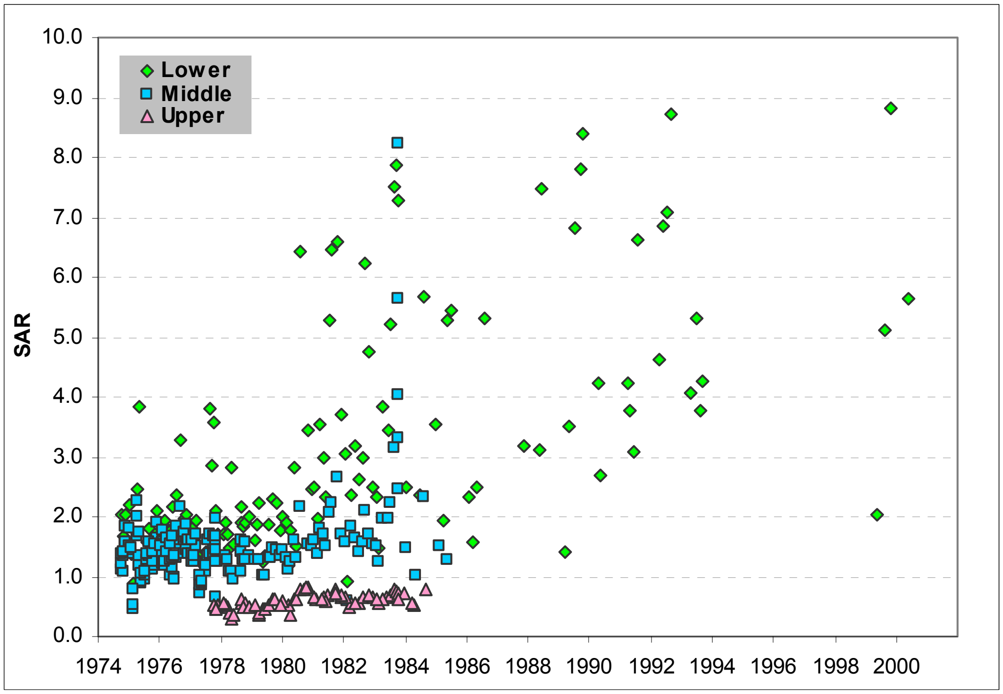

Figure 3-14. SAR data for Rosebud Creek (all stations).

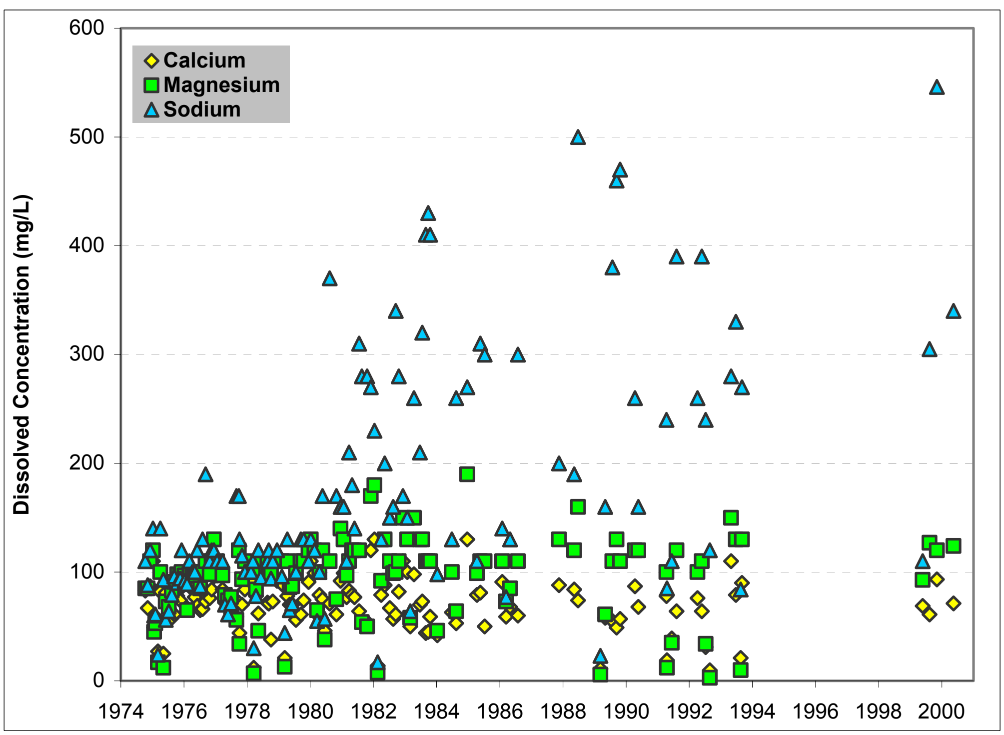

Figure 3-15. Calcium, magnesium, and sodium concentrations for lower Rosebud Creek (all stations).

3.4.3.5 Metals

Rosebud Creek was divided into four segments for the Montana 2002 303(d) list – lower Rosebud Creek, middle Rosebud Creek, upper Rosebud Creek, and Rosebud Creek Northern Cheyenne Reservation. As described in Section 3.4, two segments of Rosebud Creek (i.e., the lower and middle Rosebud Creek) were listed as impaired for metals on the 1996 list. In 2002, metals were not identified as a cause of impairment for aquatic life or fishery uses in the lower or middle segments of Rosebud Creek. Aquatic life and fishery beneficial uses were not evaluated for the upper segment of Rosebud Creek in 2002. This section presents an updated evaluation of all segments of Rosebud Creek to verify the impairment status relative to metals.

Recent metals data (1996-2002) were available at station 06296003 in the lower Rosebud Creek. No recent metals data were identified for the middle or upper segments of Rosebud Creek. Metals data for the lower segment of Rosebud Creek are summarized in Table 3-26. Both the copper and zinc acute standard were exceeded one time between 1996 and 2002. Single samples of cadmium, copper, lead, nickel, and zinc exceeded the chronic metals standards. However, average metals concentrations for the time period did not exceed any of the chronic standards.

The lower segment of Rosebud Creek is impaired because of metals. Copper and zinc are impairing aquatic life uses in this segment. This is based on the exceedances of the acute standards for both parameters at USGS station 06296003. A water quality impairment determination cannot be made for the middle and upper segments of Rosebud Creek because there is a lack of recent data. The most recent metals data in these segments were collected in 1985.

Table 3-26. Summary of TR metals data at station 06296003, lower Rosebud Creek (1996-2002).

Parameter	Total # of Samples	Acute			Chronic		
		Criteria (µg/L)	Total # of Exceedances	Percent Exceeding	Criteria (µg/L)	Total # of Exceedances	Percent Exceeding
Arsenic	8	340	0	0%	150	0	0%
Cadmium[a]	8	Variable	0	0%	Variable	1	13%
Chromium[a]	8	Variable	0	0%	Variable	0	0%
Copper[a]	8	Variable	1	13%	Variable	1	13%
Iron	0	NA	NA	NA	1,000	NA	NA
Lead[a]	8	Variable	0	0%	Variable	1	13%
Nickel[a]	8	Variable	0	0%	Variable	1	13%
Selenium	0	20	NA	NA	5	NA	NA
Silver[a]	0	Variable	NA	NA	NA	NA	NA
Zinc[a]	8	Variable	1	13%	Variable	1	13%

[a]Hardness–dependent criteria (hardness as mg/L of $CaCO_3$).

3.4.3.6 Total Suspended Solids

Rosebud Creek was divided into four segments for the Montana 2002 303(d) list – lower Rosebud Creek, middle Rosebud Creek, upper Rosebud Creek, and Rosebud Creek Northern Cheyenne Reservation. As described in Section 3.4, two segments of Rosebud Creek (i.e., the lower and middle Rosebud Creek) were listed as impaired for total suspended solids (TSS) on the 1996 list. In 2002, TSS was not identified as a cause of impairment for aquatic life or fishery uses in the lower or middle segments of Rosebud Creek. Aquatic life and fishery beneficial uses were not evaluated for the upper segment of Rosebud Creek in 2002 because of insufficient credible data. This section presents an updated evaluation of all segments of Rosebud Creek to verify the impairment status relative to TSS.

There are no numeric water quality standards for TSS in Montana, and no reference conditions are available for Rosebud Creek at this time. Both Utah and South Dakota have a TSS criterion of 90 mg/L for the protection of warmwater fishery streams, and South Dakota also has a criterion of 150 mg/L for the protection of marginal warmwater fishery streams. The 90 mg/L and 150 mg/L criteria were compared to the TSS data from Rosebud Creek to provide some insight on use impairment status. However, a better target for prairie streams is needed to make more conclusive decisions.

A general summary of TSS data is shown in Table 3-27 and all TSS data for Rosebud Creek are shown in Figure 3-16. There does not appear to be an increasing or decreasing trend in TSS concentrations. Concentrations appear to be highest in the lower segment of Rosebud Creek. All of the average and median concentrations exceeded the 90 mg/L target for TSS except at station 06295113. There was not a strong relationship between TSS and flow at station 06296003 (Figure 3-17). The Montana 2002 303(d) list assessment record for the middle segment of Rosebud Creek indicated that riparian and channel conditions were very good throughout the reach (MDEQ, 2002a).

A final water quality impairment determination will not be made for suspended solids because appropriate information is not yet available to determine if the elevated concentrations are a result of natural or anthropogenic causes. Also, a water quality impairment determination cannot be made for the middle and upper segments of Rosebud Creek because there is a lack of recent data. The most recent SAR data were collected in 1985.

Table 3-27. Summary of TSS data, Rosebud Creek (mg/L).

Station	Count	Average	Median	Min	Max	CV[a]	Min Date	Max Date
Lower								
06296003	141	708	149	35	21,600	333%	10/10/74	4/10/02
Middle								
06295250	94	167	92	17	1,040	124%	10/9/74	5/14/85
06295400	37	176	94	12	822	111%	10/9/74	9/29/77
06295500	33	341	247	18	946	80%	10/10/74	5/25/77
Upper								
06295110	18	185	95.5	12	624	103%	10/4/77	9/10/79
06295113	38	90	76.5	33	463	80%	12/10/79	8/30/84

[a]CV – Coefficient of Variation (standard deviation/mean).

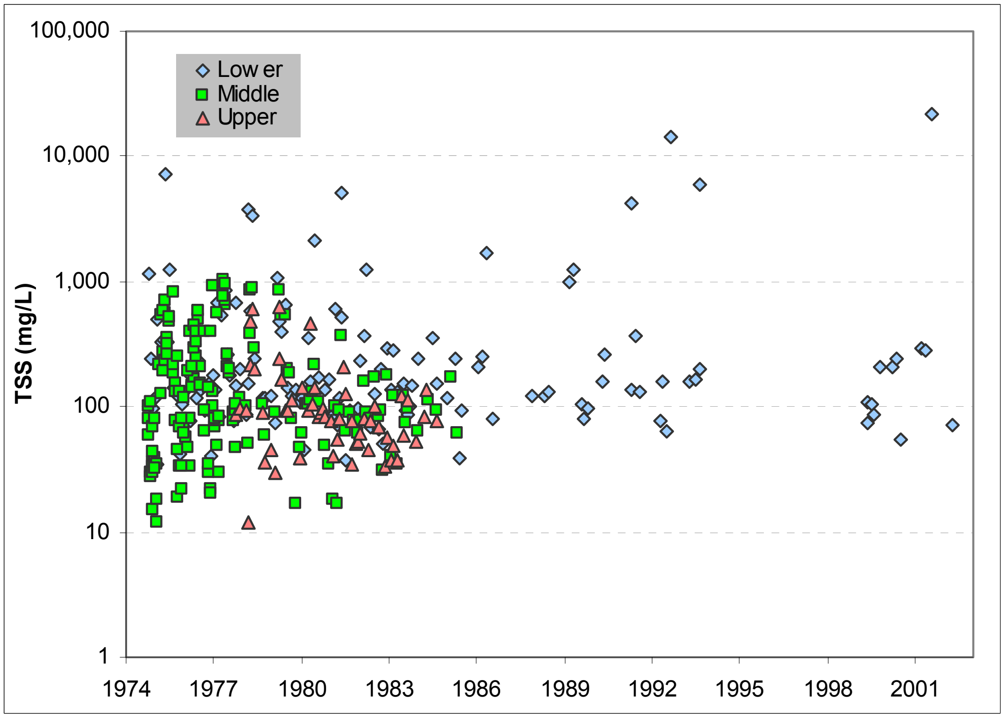

Figure 3-16. TSS data for Rosebud Creek (all stations).

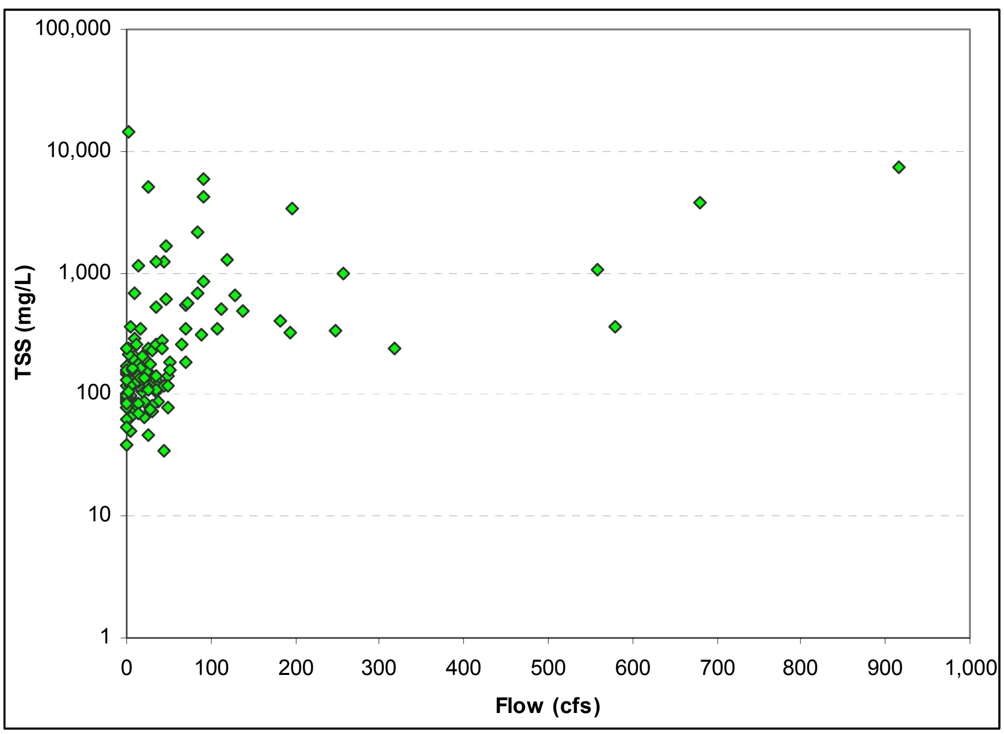

Figure 3-17. Relationship between TSS and flow at station 06296003.

3.4.3.7 Nutrients

Rosebud Creek was divided into four segments for the Montana 2002 303(d) list – lower Rosebud Creek, middle Rosebud Creek, upper Rosebud Creek, and Rosebud Creek Northern Cheyenne Reservation. As described in Section 3.4, two segments of Rosebud Creek (i.e., the lower and middle Rosebud Creek) were listed as impaired for nutrients on the 1996 list. In 2002, fishery uses in the middle Rosebud Creek were impaired because of nutrients. Nutrients were not identified as a cause of impairment in the lower segment of Rosebud Creek in 2002, and the upper segment of Rosebud Creek was not assessed because of insufficient credible data. This section presents an updated evaluation of all segments of Rosebud Creek to verify the impairment status relative to nutrients.

Few states, including Montana, have numeric nutrient standards. This is because natural concentrations of nutrients vary among streams. Also, aquatic life and stream response to nutrient concentrations vary with different systems. Table 3-28 presents a summary of nutrient standards and guidelines from different states. Included in Table 3-28 are the nutrient standards developed for the Clark Fork River in Montana. Ohio Environmental Protection Agency (OEPA) nutrient guidelines are based on biological response to nutrients and are based on the size of the watershed and type of stream. OEPA standards shown in Table 3-28 are for large rivers (>1,000 square miles) and warmwater habitats.

Table 3-28. Guidelines for nutrient criteria from various states.{tc "Table 11. North Dakota nitrate and total phosphorus guidelines for Class 1 and Class 1A streams. " \f D }

State	Total Nitrogen/Nitrite/Nitrate	Total Phosphorus (P)
Montana (Clark Fork)	0.30 mg/L (Total Nitrogen)	0.039 mg/L
North Dakota	1.0 mg/L (Nitrate)	0.10 mg/L
Ohio	2.0 mg/L (Nitrite/Nitrate)	0.30 mg/L
Utah	4.0 mg/L (Nitrate)	0.05 mg/L

Sources: OEPA, 1999; UDAR, 2002.

A summary of nutrient data is presented in Tables 3-29 through 3-31. Nutrient parameters show in the tables are total phosphorus (TP), total nitrogen (TN), and nitrate plus nitrite nitrogen (NN). Station 06296003 in the lower segment of Rosebud Creek was the only station with recent data. Median total phosphorus and nitrate/nitrite concentrations were lower than Ohio and North Dakota guidelines at all stations. Tables 3-29 and 3-30 show that few TP and NN concentrations exceeded Ohio EPA proposed nutrient guidelines. The limiting nutrient, or the nutrient that limits plant growth when it is not available in sufficient quantities, appears to be phosphorus (Chapra, 1997). There was little difference in nutrient concentrations in the three segments of Rosebud Creek and no trends were apparent (Figures 3-18 through 3-20). Dissolved oxygen (DO) data are summarized in Table 3-32 and Figure 3-21. There were few DO samples exceeding the DO criteria in Rosebud Creek. Low DO concentrations do not directly measure nutrient impairments but are rather one possible result of a nutrient impairment.

A final water quality impairment determination will not be made for nutrients because appropriate information is not yet available to determine if the elevated concentrations are a result of natural or anthropogenic causes. Also, a water quality impairment determination cannot be made for the middle and upper segments of Rosebud Creek because there is a lack of recent data.

Table 3-29. Summary of total phosphorus data, Rosebud Creek (mg/L).

Station	Count	Average	Median	Min	Max	CV[a]	Min Date	Max Date
Lower								
6296003	141	0.27	0.07	0.01	9.24	340%	10/10/74	6/11/02
Middle								
454044106415601	4	0.05	0.04	0.04	0.07	32%	11/1/77	10/17/83
454806106292901	2	0.05	0.05	0.04	0.05	16%	11/1/77	10/17/83
455810106233301	1	0.04	0.04	0.04	0.04	NA	11/1/77	11/1/77
460557106264601	4	0.06	0.06	0.02	0.10	61%	11/2/77	10/18/83
460914106282201	1	0.05	0.05	0.05	0.05	NA	11/2/77	11/2/77
6295250	94	0.11	0.07	0.01	1.30	149%	10/9/74	5/14/85
6295400	38	0.10	0.06	0.01	0.45	100%	10/9/74	10/17/83
6295500	32	0.13	0.06	0.01	0.46	107%	10/10/74	5/25/77
Upper								
451302106583201	2	0.04	0.04	0.02	0.05	61%	10/31/77	10/16/83
6295110	21	0.08	0.04	0.01	0.37	130%	10/4/77	9/10/79
6295113	41	0.08	0.06	0.01	0.34	89%	10/1/79	8/30/84

[a]CV – Coefficient of Variation (standard deviation/mean).

Table 3-30. Summary of total nitrogen data, Rosebud Creek (mg/L).

Station	Count	Average	Median	Min	Max	CV[a]	Min Date	Max Date
Lower								
6296003	79	1.35	0.90	0.17	9.20	104%	10/10/74	4/1/82
Middle								
454044106415601	3	0.44	0.49	0.25	0.59	39%	11/1/77	10/25/78
454806106292901	1	0.25	0.25	0.25	0.25	NA	11/1/77	11/1/77
455810106233301	1	0.30	0.30	0.30	0.30	NA	11/1/77	11/1/77
460557106264601	3	0.86	0.69	0.49	1.40	56%	11/2/77	10/25/78
460914106282201	1	0.40	0.40	0.40	0.40	NA	11/2/77	11/2/77
6295250	73	0.95	0.76	0.09	4.30	67%	10/9/74	2/17/82
6295400	37	0.95	0.75	0.19	3.80	71%	10/9/74	11/1/77
6295500	32	0.99	0.94	0.13	1.90	51%	10/10/74	5/25/77
Upper								
451302106583201	1	0.39	0.39	0.39	0.39	NA	10/31/77	10/31/77
6295110	21	0.86	0.75	0.15	2.10	63%	10/4/77	9/10/79
6295113	22	1.05	0.97	0.46	1.90	38%	10/1/79	3/1/82

[a]CV – Coefficient of Variation (standard deviation/mean).

Table 3-31. Summary of nitrite/nitrate data, Rosebud Creek (mg/L).

Station	Count	Average	Median	Min	Max	CV[a]	Min Date	Max Date
Lower								
6296003	101	0.21	0.10	0.00	1.60	108%	10/10/74	8/26/92
Middle								
454044106415601	2	0.10	0.10	0.10	0.10	0%	11/1/77	10/17/83
454806106292901	2	0.10	0.10	0.10	0.10	0%	11/1/77	10/17/83
455810106233301	1	0.10	0.10	0.10	0.10	NA	11/1/77	11/1/77
460557106264601	1	0.10	0.10	0.10	0.10	NA	11/2/77	10/18/83
6295250	78	0.19	0.10	0.00	1.20	103%	10/9/74	5/14/85
6295400	27	0.18	0.20	0.10	0.40	51%	10/9/74	10/17/83
6295500	24	0.18	0.15	0.10	0.40	52%	10/10/74	5/25/77
Upper								
451302106583201	1	0.20	0.20	0.20	0.20	NA	10/31/77	10/16/83
6295110	21	0.20	0.10	0.10	0.50	64%	10/4/77	9/10/79
6295113	37	0.13	0.10	0.00	0.80	106%	10/1/79	8/30/84

[a]CV – Coefficient of Variation (standard deviation/mean).

Table 3-32. Summary of DO data, Rosebud Creek (mg/L).

Station	Count	Average	Median	Min	Max	CV[a]	Min Date	Max Date
Lower								
6296003	126	10.0	10.1	3.9	13.2	184%	10/10/74	9/1/93
Middle								
454044106415601	1	10.2	10.2	10.2	10.2	NA	11/1/77	11/1/77
454806106292901	1	11.4	11.4	11.4	11.4	NA	11/1/77	11/1/77
455810106233301	1	11.8	11.8	11.8	11.8	NA	11/1/77	11/1/77
460557106264601	1	8.5	8.5	8.5	8.5	NA	11/2/77	11/2/77
460914106282201	1	8.2	8.2	8.2	8.2	NA	11/2/77	11/2/77
6295250	93	9.7	9.6	4.6	13.8	201%	10/9/74	5/14/85
6295400	36	9.7	9.7	6.5	13.8	199%	10/9/74	11/1/77
6295500	32	10.1	10.6	5.9	12.7	205%	10/10/74	5/25/77
Upper								
451302106583201	1	11.9	11.9	11.9	11.9	NA	10/31/77	10/31/77
6295110	19	10.0	10	7.8	12.6	143%	10/4/77	9/10/79
6295113	40	9.4	9.6	5.9	12.4	192%	10/1/79	8/30/84

[a]CV – Coefficient of Variation (standard deviation/mean).

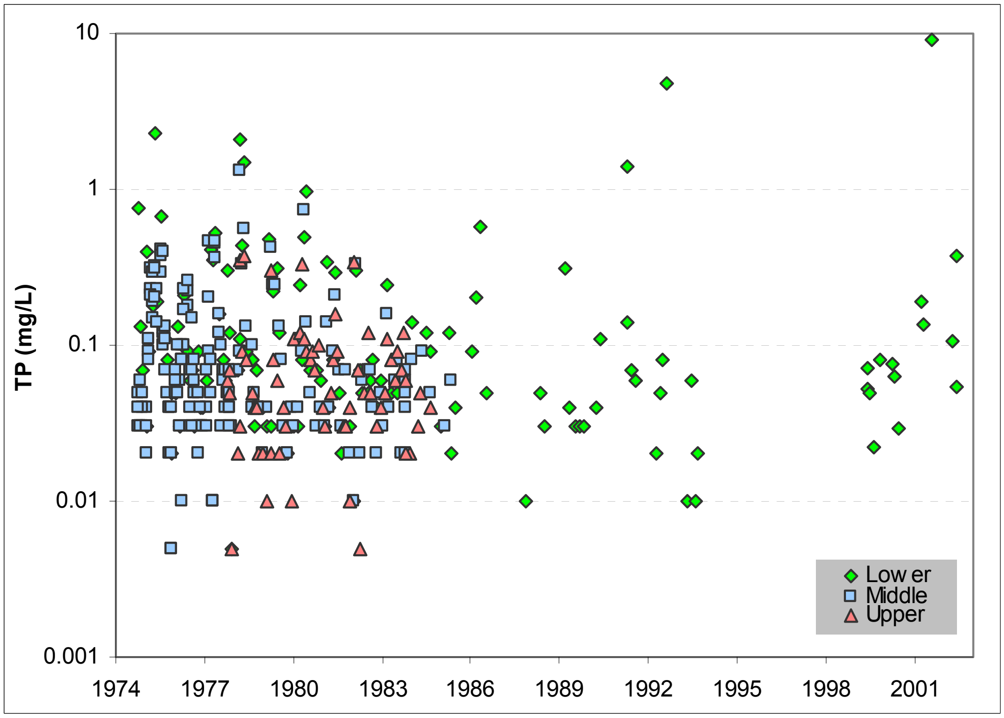

Figure 3-18. TP data for Rosebud Creek (all stations).

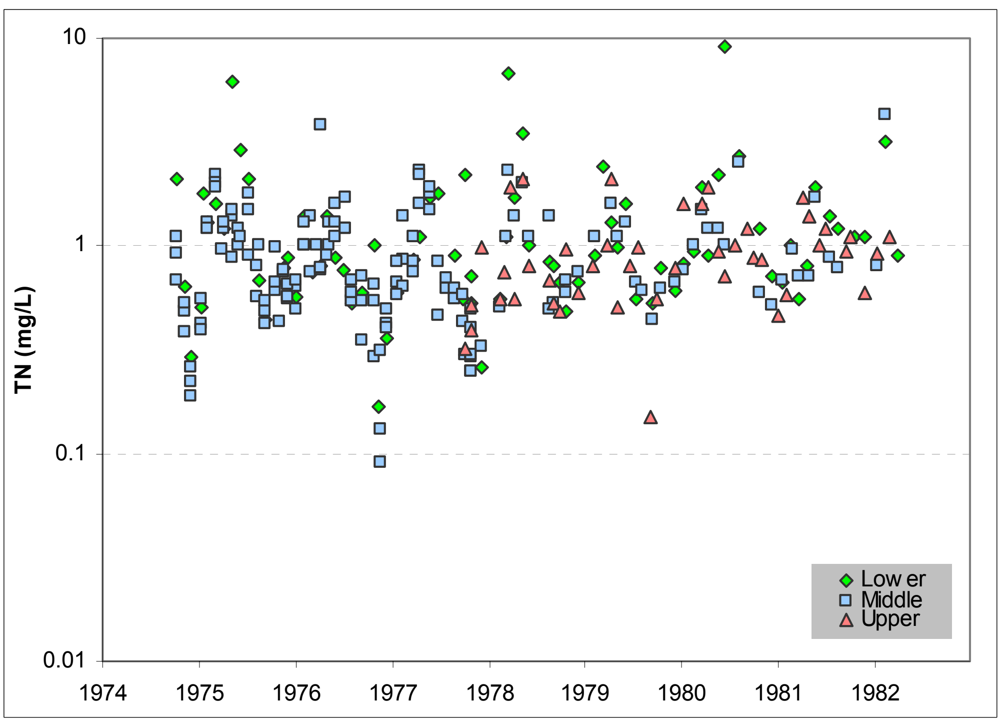

Figure 3-19. TN data for Rosebud Creek (all stations).

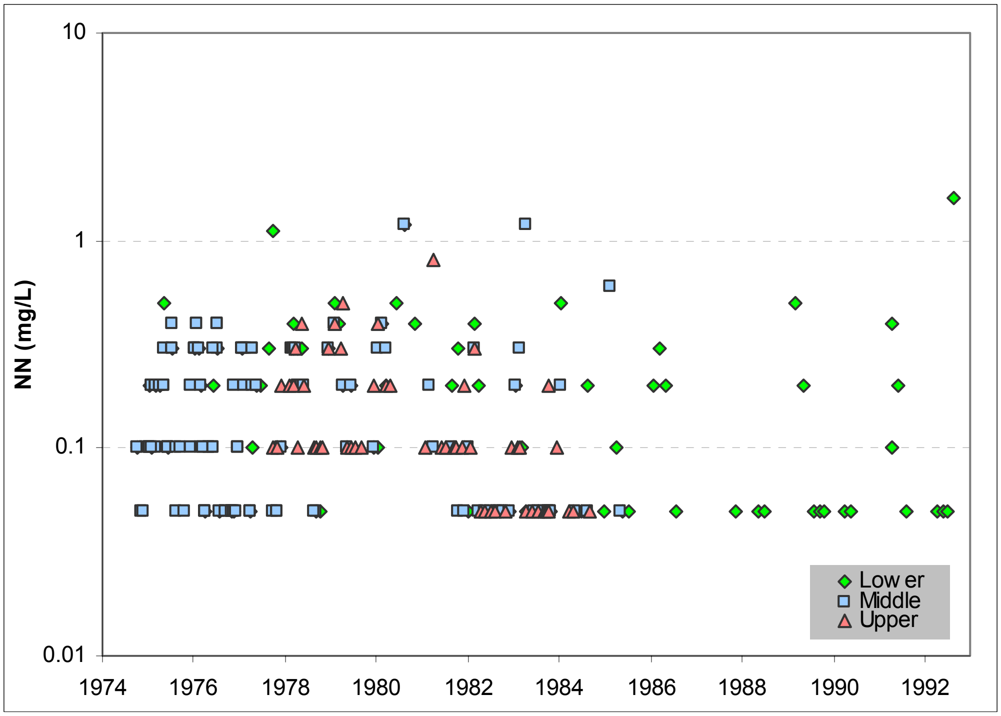

Figure 3-20. NN data for Rosebud Creek (all stations).

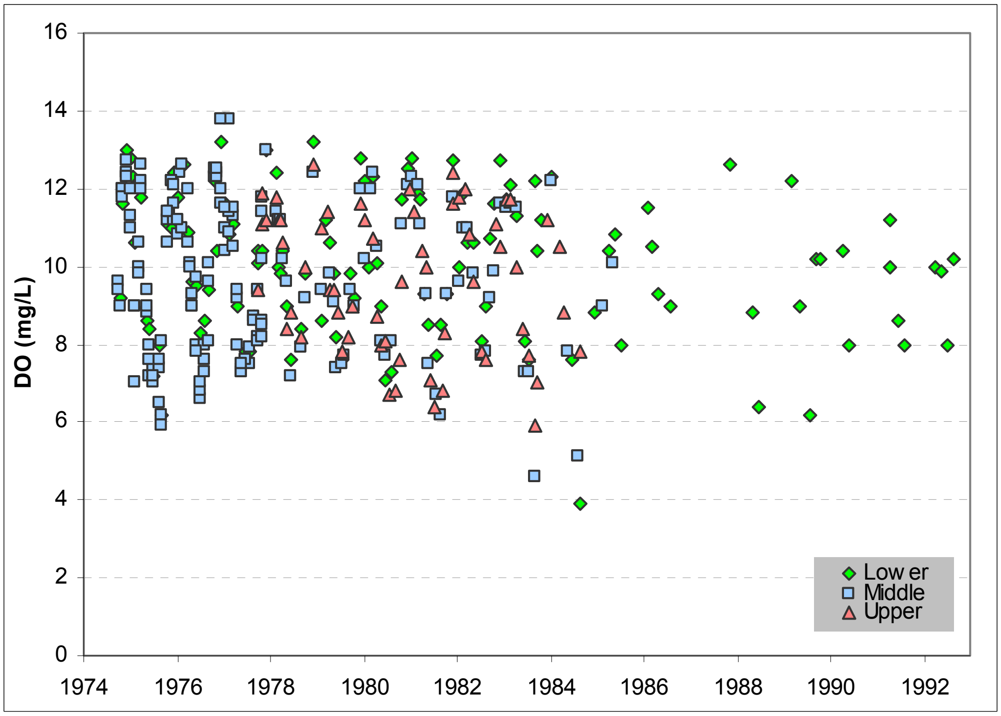

Figure 3-21. Dissolved oxygen data for Rosebud Creek (all stations).

3.4.3.8 Other Inorganics (Sulfate)

Rosebud Creek was divided into four segments for the Montana 2002 303(d) list – lower Rosebud Creek, middle Rosebud Creek, upper Rosebud Creek, and Rosebud Creek Northern Cheyenne Reservation. As described in Section 3.4, two segments of Rosebud Creek (i.e., the lower and middle Rosebud Creek) were listed as impaired for other inorganics (sulfates) on the 1996 list. Agricultural uses in Rosebud Creek were not evaluated for the 2002 303(d) list, and sulfate was not identified as a cause of impairment for any other beneficial uses. This section presents an updated evaluation of all segments of Rosebud Creek to verify the impairment status relative to sulfates.

TDS targets for three segments of Rosebud Creek were described in Section 3.4.3.2. These targets were used to help determine sulfate impairments in Rosebud Creek because TDS is partially composed of sulfates. By definition, the dissolved sulfate concentration in a stream must be equal to or less than the TDS concentration. At station 06296003, sulfates were on average 43 percent of the TDS in the river.

Tables 3-33 and 3-34 summarize the sulfate data for Rosebud Creek. Sulfate concentrations were generally higher than the secondary drinking water standard of 250 mg/L. Several samples in the lower and middle segments of Rosebud Creek exceeded the calculated TDS targets (Figures 3-22 through 3-24).

A final water quality impairment determination will not be made for sulfate until the Montana Board of Environmental Review makes their final decision regarding the adoption of numeric criteria for salinity (EC) (see Section 3.3.1.2). Also, a water quality impairment determination cannot be made for the upper segment of Rosebud Creek because there is a lack of current data. The most recent sulfate data were collected in 1984.

Table 3-33. Summary of sulfate data, Rosebud Creek (mg/L) (November 1–March 31).

Station	Count	Average	Min	Max	CV[a]	Min Date	Max Date
Lower							
6296003	45	444	16	1,230	56%	11/8/74	11/5/99
Middle							
454044106415601	1	270	270	270	NA	11/1/77	11/1/77
454806106292901	1	320	320	320	NA	11/1/77	11/1/77
455810106233301	1	360	360	360	NA	11/1/77	11/1/77
460557106264601	1	390	390	390	NA	11/2/77	11/2/77
460914106282201	1	360	360	360	NA	11/2/77	11/2/77
6295250	37	331	54	580	28%	11/7/74	2/22/85
6295400	16	329	62	430	25%	11/7/74	11/1/77
6295500	15	348	62	440	31%	11/8/74	3/23/77
Upper							
6295110	8	145	120	180	16%	11/1/77	3/27/79
6295113	16	168	140	210	12%	12/10/79	3/21/84

[a]CV – Coefficient of Variation (standard deviation/mean).

Table 3-34. Summary of sulfate data, Rosebud Creek (mg/L) (April 1–October 31).

Station	Count	Average	Min	Max	CV[a]	Min Date	Max Date
Lower							
6296003	89	582	96	1,290	48%	10/10/74	6/11/02
Middle							
454044106415601	3	427	300	670	49%	8/24/78	10/17/83
454806106292901	1	1,600	1,600	1,600	0%	10/17/83	10/17/83
460557106264601	3	1,123	430	2,500	106%	8/24/78	10/18/83
6295250	58	383	190	1,000	46%	10/9/74	5/14/85
6295400	22	379	200	1,600	75%	10/9/74	10/17/83
6295500	17	341	210	600	31%	10/10/74	5/25/77
RBC001	3	327	325	330	1%	5/31/01	6/19/01
USGS001	2	114	114	114	0%	6/19/01	6/19/01
Upper							
451302106583201	2	250	200	300	28%	10/31/77	10/16/83
6295110	13	142	100	190	17%	10/4/77	9/10/79
6295113	25	156	120	200	15%	10/1/79	8/30/84

[a]CV – Coefficient of Variation (standard deviation/mean).

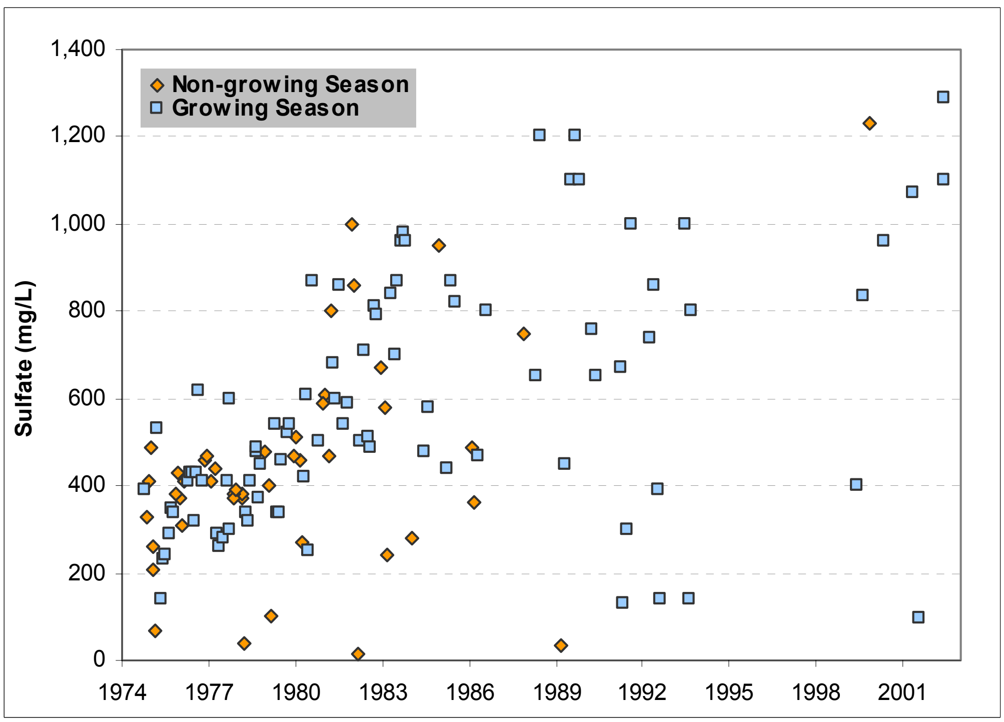

Figure 3-22. Sulfate data for lower Rosebud Creek (all stations).

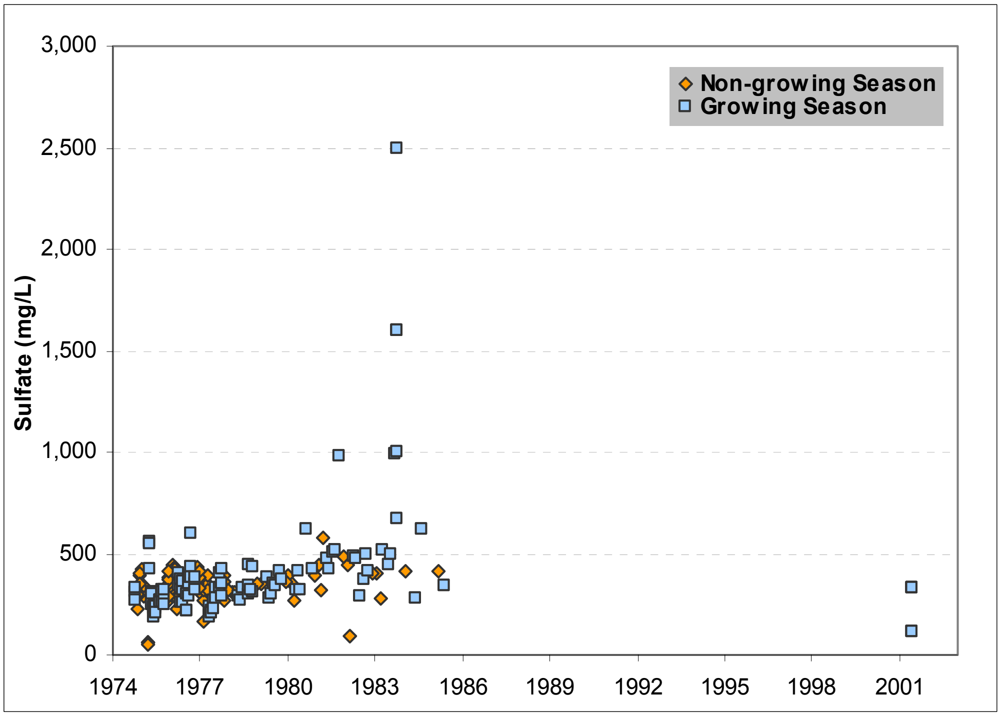

Figure 3-23. Sulfate data for middle Rosebud Creek (all stations).

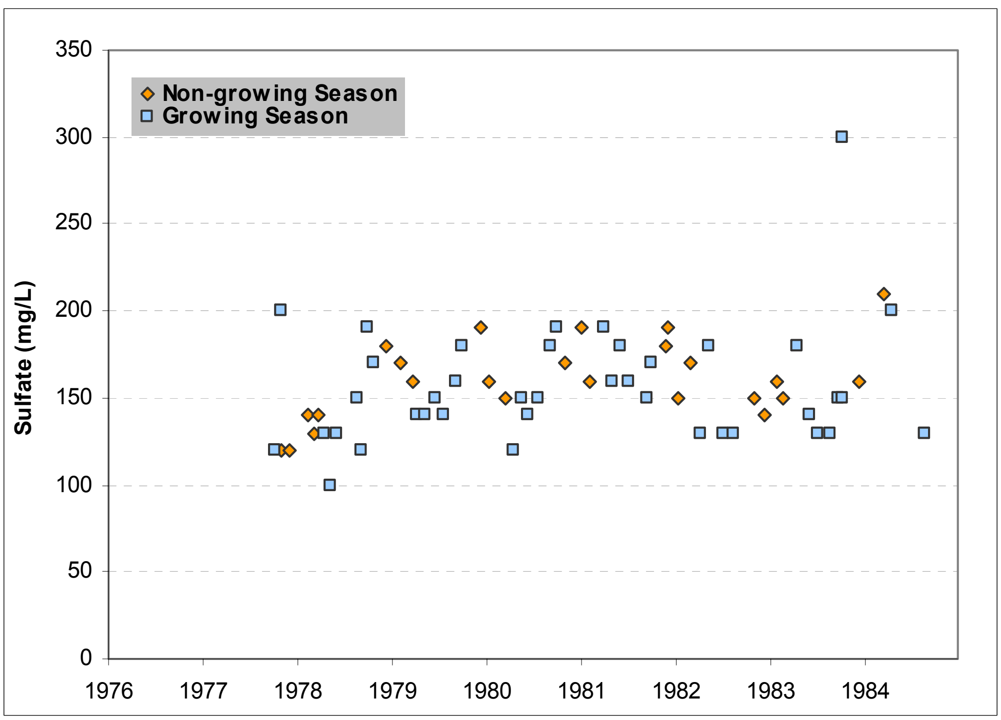

Figure 3-24. Sulfate data for upper Rosebud Creek (all stations).

3.4.3.9 Water Quality Impairment Status: Rosebud Creek

The Montana 1996 303(d) list reported that Rosebud Creek from the mouth to the Northern Cheyenne Reservation boundary was impaired because of flow alterations, metals, nutrients, other inorganics, salinity/TDS/chlorides, and suspended solids. Impairments due to other inorganics are believed to refer to sulfate. Aquatic life and fishery uses were impaired by these causes in 1996.

In 2002, using additional data and a new listing methodology, MDEQ identified Rosebud Creek from the mouth to an irrigation dam 3.8 miles upstream (lower Rosebud Creek) as impaired because of bank erosion and other habitat alterations. Aquatic life and fishery uses were impaired in this segment because of these causes. Rosebud Creek from the diversion dam to the Northern Cheyenne Reservation boundary (middle Rosebud Creek) was impaired because of nutrients and other habitat alterations in 2002. Fishery uses in this segment were impaired by these causes. Other uses, including industrial, agricultural, recreational, and drinking water uses were not assessed in these segments because of insufficient credible data. No information was provided on the 1996 or 2002 lists for the upper segment of Rosebud Creek (from the headwaters to the southern boundary of the Northern Cheyenne Reservation).

The 1996 causes of impairment were analyzed in the previous sections to determine which causes will require TMDLs. Water quality impairment determinations could not be made for several causes of impairment because appropriate site-specific numeric criteria have not been identified, or because there was a lack of recent data. A summary for each evaluated cause of impairment for each segment of Rosebud Creek is shown in Table 3-35.

Table 3-35. Water quality impairment status summary.

Segment	Evaluated Cause of Impairment	1996 303(d) List	2002 303(d) List[a]	TMDL Requirement
Rosebud Creek - from the mouth 3.8 miles upstream to an irrigation dam (Lower Rosebud Creek)	Bank erosion		✔	No
	Chlorides	✔		No
	Flow alteration	✔		No
	Metals	✔		Yes
	Nutrients	✔		Undetermined
	Other habitat alterations		✔	No
	Other Inorganics	✔		Undetermined
	Salinity	✔		Undetermined
	SAR			Undetermined
	Suspended Solids	✔		Undetermined
	TDS	✔		Undetermined
Rosebud Creek - from the Northern Cheyenne Reservation boundary to the irrigation dam (Middle Rosebud Creek)	Chlorides	✔		Undetermined
	Flow alteration	✔		No
	Metals	✔		Undetermined
	Nutrients	✔	✔	Undetermined
	Other habitat alterations		✔	Undetermined
	Other Inorganics	✔		Undetermined
	Salinity	✔		Undetermined
	SAR			Undetermined
	Suspended Solids	✔		Undetermined
	TDS	✔		Undetermined
Rosebud Creek – from the headwaters to the southern border of the Northern Cheyenne Reservation (Upper Rosebud Creek)	Chlorides			Undetermined
	Flow alteration			No
	Metals			Undetermined
	Nutrients			Undetermined
	Other Inorganics			Undetermined
	Salinity			Undetermined
	SAR			Undetermined
	Suspended Solids			Undetermined
	TDS			Undetermined

[a]Not all causes of impairment were evaluated for the 2002 303(d) list.
Source: MDEQ, 1996, 2002.

4.0 CONCEPTUAL MONITORING PLAN

The purpose of this section is to identify data gaps and recommend additional monitoring strategies for the Rosebud Creek watershed. The goals of the additional monitoring are to determine beneficial use impairments, obtain data for setting up and calibrating a watershed/water quality model, and better determine sources of impairment. The amount of current, reliable data is directly linked to the level of confidence in the results of the TMDL process. The more data that can be collected, the easier it will be to determine the current impairment status, appropriate water quality targets, and existing and allowable loadings for the Rosebud Creek watershed. The monitoring plan presented below is a *conceptual plan* and provides a preliminary framework for the final monitoring strategy. A more detailed sampling and analysis plan is being prepared.

4.1 Identified Data Gaps

4.1.1 Beneficial Use Determinations

Section 3.0 summarized all available data relative to the water quality limited segments identified on the 1996 303(d) list. In many cases, insufficient data were available to make final water quality impairment determinations. The identified data gaps are summarized in Table 4-1. The purpose of this monitoring section is to develop a detailed strategy to fill these gaps.

4.1.2 Model Calibration

As discussed in Section 1.3.2, it is expected that during Phase III some sort of watershed and water quality modeling will need to be performed to establish the relationship between the in-stream water quality targets and the source loadings. Using models allows for the evaluation of management options and the selection of the option that will achieve the desired source load reductions in the most efficient manner. Although a specific model has not yet been identified, one of the purposes of the data collection activities will be to collect the data that are necessary to setup, apply, calibrate, and validate the model. The data that will likely be needed to setup and calibrate whichever model is chosen include the following:

- Hourly precipitation and temperature data for representative areas of the watershed.
- Flow data at multiple main stem and tributary stations for hydrologic calibration and validation of the model.
- Stream cross sections for the lower, upper, and middle segments of Rosebud Creek.
- Water quality data at multiple main stem and tributary stations to calibrate the model. Additional data will be necessary at the same stations for model validation.
- Sampling of significant sources, such as mining, oil and gas development, and irrigation return flows, to better characterize these sources within the model.
- Shallow groundwater sampling to characterize the interaction between groundwater and surface waters.

Table 4-1. Identified data gaps in the Rosebud Creek watershed.

Water Body	Pollutant	Identified Data Gap
Rosebud Creek – from the mouth 3.8 miles upstream to an irrigation dam (Lower Rosebud Creek)	Salinity/TDS/Chlorides	• Lack of final, approved numeric criteria • Lack of recent data
	SAR	• Lack of final, approved numeric criteria
	Metals	• None
	Suspended Solids	• Lack of comparable reference condition or suitable target • Insufficient data to define the natural conditions
	Nutrients	• Insufficient data to define the natural conditions • Lack of final, approved numeric criteria • Lack of recent data
Rosebud Creek – from the Northern Cheyenne Reservation Boundary to the irrigation dam (Middle Rosebud Creek)	Salinity/TDS/Chlorides	• Lack of final, approved numeric criteria • Lack of recent data
	SAR	• Lack of final, approved numeric criteria • Lack of recent data
	Metals	• Lack of recent data
	Suspended Solids	• Lack of comparable reference condition or suitable target • Insufficient data to define the natural conditions • Lack of recent data
	Nutrients	• Insufficient data to define the natural conditions • Lack of final, approved numeric criteria • Lack of recent data
Rosebud Creek – from the headwaters to the southern border of the Northern Cheyenne Reservation (Upper Rosebud)	Salinity/TDS/Chlorides	• Insufficient data to define the natural conditions • Lack of final, approved numeric criteria • Lack of recent data
	SAR	• Insufficient data to define the natural conditions • Lack of final, approved numeric criteria
	Metals	• Lack of recent data
	Suspended Solids	• Lack of comparable reference condition or suitable target • Insufficient data to define the natural conditions • Lack of recent data
	Nutrients	• Insufficient data to define the natural conditions • Lack of final, approved numeric criteria • Lack of recent data

4.1.3 Source Assessment

TMDLs must consider all significant sources of a pollutant (e.g., the source of excessive algal growth in a stream are nutrients from a municipal wastewater treatment plant and an animal feeding operation). It is necessary to identify and quantify the relative contribution from all potentially significant sources for each pollutant. A summary of the listed pollutants and their associated potential sources in the Rosebud Creek watershed is provided in Table 4-2. To date, little work has been conducted in the Rosebud Creek watershed to identify and estimate loading rates from those pollutants appearing on the 1996 303(d) list.

Table 4-2. Pollutants and their potential sources in the Rosebud Creek watershed.

Water Body	Pollutant	Potential Sources
Rosebud Creek	Salinity/TDS/Chlorides	• Industrial point sources • Mining; oil and CBM development • Natural sources (geology and soils)
	SAR	• Industrial point sources • Mining; oil and CBM development • Natural sources (geology and soils)
	Suspended Solids	• Agriculture • Channel erosion and scouring • Natural sources (geology and soils) • Pasture/range grazing
	Metals	• Industrial point sources • Mining; oil and CBM development • Natural sources (geology and soils)
	Nutrients	• Animal feeding operations • Agriculture • Fisheries • Recreation • Wastewater disposal

4.2 Monitoring Strategy

There are four different types of data that need to be collected for the 2003 sampling program:

- Data for listed segments and parameters where there is no current data.
- Data to quantify sources in Rosebud Creek and tributaries.
- Data to assess the natural or background conditions of the listed parameters.
- Data to run and calibrate a model.

All four types of data will help to make beneficial use determinations for the listed segments and to develop TMDLs for those segments that are indeed impaired. The following sections outline the additional monitoring sites and needed data.

4.2.1 Data Gap – No Current Data

4.2.1.1 Tributaries

There are few recent data for tributaries in the Rosebud Creek watershed. However, some data exists at tributary stations sampled by the Northern Cheyenne Tribe. Salinity (EC), SAR, TDS, DO, turbidity, nutrients (nitrogen and phosphorus), and TSS data should be collected at or near these historic sites so that current data (2003) can be compared to the historic data. Also, new tributary monitoring sites should be established to better characterize tributary conditions in the watershed.

4.2.1.2 Rosebud Creek

There are current data for the lower segment of Rosebud Creek for most parameters. However, there are few recent samples for the middle and upper segments of Rosebud Creek. Salinity (EC), SAR, TDS, DO, turbidity, nutrients, and TSS data should be collected at or near historic monitoring sites so that current data (2003) can be compared to the historic data. The recommended sites are shown in Table 4-3 and

Figure 4-1. There are few current metals data for the Rosebud Creek watershed. Metals samples should be collected in all four segments of the river to help determine if metals are impairing uses. Recommended metals sampling includes arsenic, cadmium, chromium, copper, iron, lead, nickel, selenium, silver, and zinc. Biological assemblages (macroinvertebrates, fish, algae) should be sampled at these sites as well.

Table 4-3. 2003 metals sampling sites for the main stem Rosebud Creek.

USGS Site Number	Site Name	Latitude	Longitude
06296003	Rosebud Creek at the mouth near Rosebud, Montana	46.2647	-106.4750
06295500	Rosebud Creek near Rosebud, Montana	46.1128	-106.4522
06295400	Rosebud Creek above Pony Creek near Colstrip, Montana	45.8925	-106.4008
06295250	Rosebud Creek near Colstrip, Montana	45.7675	-106.5694
06295113	Rosebud Creek at the Reservation Boundary near Kirby, Montana	45.3611	-106.9897

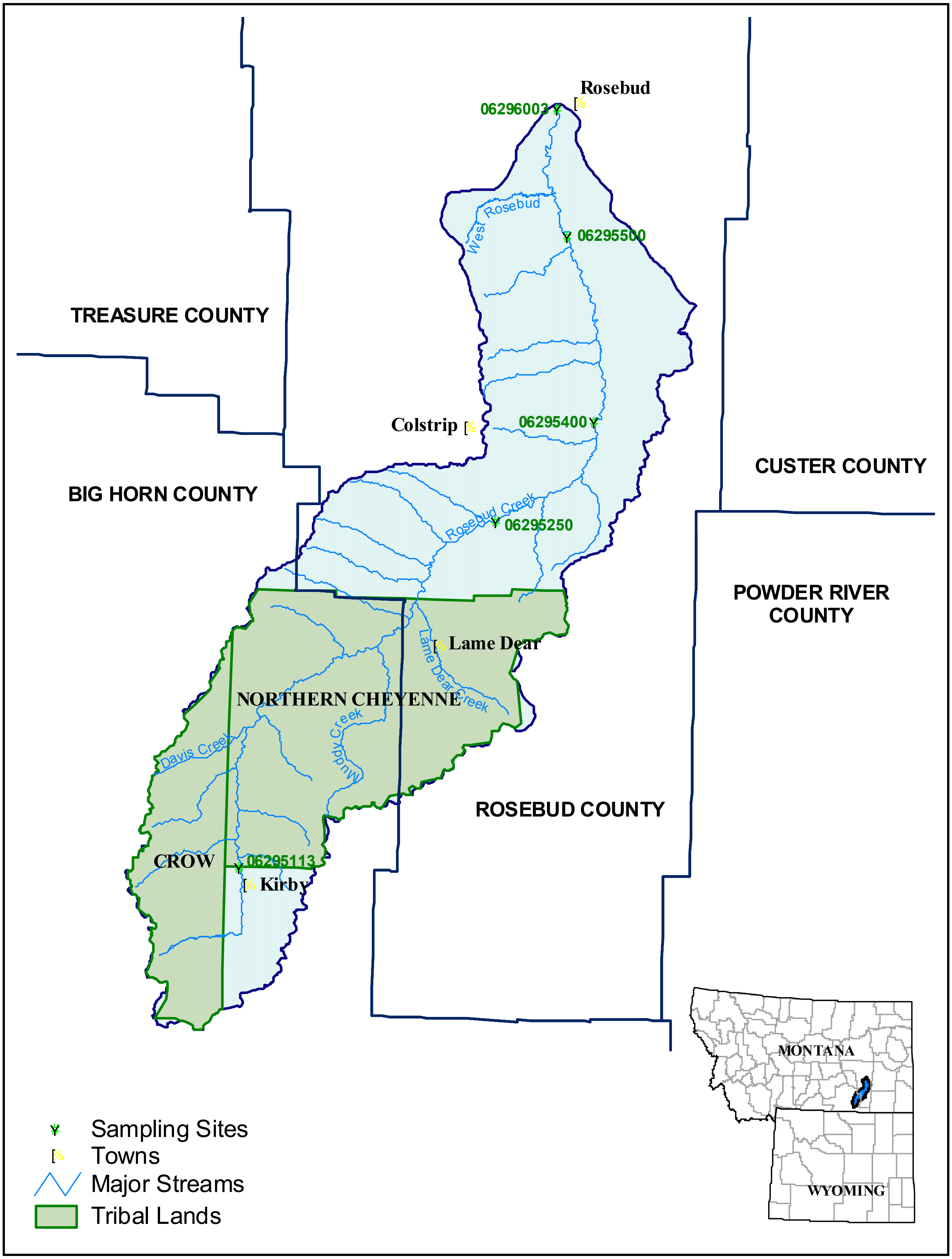

Figure 4-1. 2003 main stem sampling sites for the Rosebud Creek watershed.

4.2.2 Data Gap – Sources

There are few data or studies assessing potential sources of impairment in the Rosebud Creek watershed. Potential sources of impairment are irrigation, grazing, animal feeding operations, fisheries, channel erosion, natural sources, industrial sources, and mining/oil/CBM operations. A monitoring approach for quantifying the effect of these sources is outlined below.

- Identify and monitor major irrigation return flows for flow and water chemistry
- Identify and monitor upstream and downstream of major agricultural areas
- Monitor shallow groundwater aquifers for water chemistry
- Monitor downstream of major mining, oil, and gas development activities
- Monitor downstream of major wastewater discharges (treatment plants and areas with high septic system densities)
- Monitor instream erosion using the Bank Erosion Hazard Index (BEHI) methodology

The following sections describe the monitoring approach to help locate and quantify major sources of impairment in the Rosebud Creek watershed.

4.2.2.1 Irrigation Return Flows

Irrigation return flows are a potential source of contaminants and little data are available. Irrigation returns should be identified and monitored for quality and quantity. Returns from different irrigation practices, soil types, and crops should be monitored. Examples include returns from flood irrigation, spreader dike systems, and sprinkler based systems. The monitoring approach is outlined below.

- Identify all irrigation return flows during a field assessment
- Identify sites with different irrigation practices, soils, and crops
- Locate appropriate water chemistry sampling sites
- Obtain permission from the landowners for sampling
- Perform water chemistry sampling (EC, TDS, SAR, and chlorides) and obtain flow data

Several irrigation return flow sites should be monitored in the Rosebud Creek watershed to determine the salinity contribution from a variety of different conditions. The sites should be monitored during the growing season and specifically after periods of irrigation if possible. All possible irrigation returns should also be identified to quantify the total load contributed by irrigation. Shallow groundwater wells should be identified and monitored where available.

4.2.2.2 Mining

There is currently not a good understanding of how mining, oil, and gas development affect water quality in Rosebud Creek. Also, the location of many of these sites is unknown. The first step to developing a monitoring plan to address these potential sources is to identify all mining-related sources, source types, and locations. Monitoring at or near the potential sources of pollution should occur for EC, TDS, SAR, and chlorides.

4.2.2.3 Streambank Erosion

Streambank erosion is a potential source of sediment in Rosebud Creek. Several methods exist for measuring and predicting streambank erosion depending on the measured amount of erosion over time and several bank stability factors. One such technique is the bank erosion hazard index (BEHI). BEHI measurements should be made along similar reaches of the main stem of Rosebud Creek and the major tributaries. An approach for quantifying sediment loads from streambank erosion is outlined below.

- Identify unique segments of the Rosebud Creek based on streambanks by rafting or walking portions of the river.
- Partition the river into several similar segments based on the assessment.
- Perform a BEHI measurement for each segment prior to the spring snowmelt season.
- Install bank erosion pins at each BEHI location during the initial BEHI measurement.
- Measure streambank erosion using the bank pins after the snowmelt season (July) and again in the fall (October).

By knowing the BEHI score and the total length of a segment, a total volume of sediment load from streambank erosion can be estimated. Pebble counts should also be performed to determine size of bed material in the channel. This should be performed during the July and October sampling periods. An aerial photograph analysis could also help to quantify streambank erosion and channel movement.

4.2.2.4 Other Potential Sources

Other potential sources, such as industrial and municipal sources, should be identified during a field assessment of the Rosebud Creek watershed. If it is suspected during the field assessment that the potential source is contributing a significant amount of pollution to the river, it should be monitored as part of the 2003 monitoring plan.

4.2.2.5 Continuous Data Monitoring

A data probe, such as a YSI or Hydrolabs sensor, can be used to obtain continuous samples at small specified intervals (e.g., hourly). Data probes generally come with sensors to obtain DO, temperature, turbidity, and EC data. Data from these sensors would help to characterize the water chemistry of the river on a daily basis, and the data would supplement ambient sampling by USGS and MDEQ.

A continuous sample data probe is recommended for the main stem of Rosebud Creek. The probe would obtain hourly readings for EC, turbidity, and DO. The continuous readings would provide information on conditions during low and high-flow events, which can be used for multiple reasons such as setting up and calibrating a model, and obtaining information on background conditions. The probes should be installed at or near current USGS flow gages to ensure that accurate flow readings accompany the data. Recommended sites are 06296003 and 06324500, and continuous flow should be monitored at these gages during the sampling period of the data probe. Also, periodic TSS and TDS concentrations should be sampled at these sites so that relationships can be developed between turbidity and sediment, and EC and TDS.

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APPENDIX A: MAJOR LAND RESOURCE AREAS DATA DESCRIPTION

58A—Northern Rolling High Plains, Northern Part
Montana

Land use: Most of this area consists of privately owned ranches. The remainder is federally owned. Most of it is in native grasses and shrubs grazed by cattle and sheep. The rest is mainly dry-farmed to wheat. Narrow strips of land along the Yellowstone River and its main tributaries are irrigated. Sugar beets, alfalfa, other hay crops, and corn for silage are the principal crops. Some of the land is in tame pasture. The upper slopes and tops of some of the higher buttes and mountains are open woodland.

Elevation and topography: Elevation generally ranges from 900 to 1,800 m, increasing from east to west and from north to south, but in a few mountains it is as high as 2,100 m. These dissected plains are underlain by shale, siltstone, and sandstone. Slopes are mostly gently rolling to steep, and wide belts of steeply sloping badland border a few of the larger river valleys. Local relief is mainly in meters to tens of meters. In places, flat-topped, steep-sided buttes rise sharply above the general level of the plains.

Climate: *Average annual precipitation*-300 to 500 mm in most of the area and as much as 750 mm in the mountains, but it fluctuates widely from year to year. Maximum precipitation is in spring and early in autumn. Precipitation in winter is snow. *Average annual temperature*-4 to 7 C. *Average freeze-free period*-120 to 140 days.

Water: The low and erratic precipitation is the principal source of water for agriculture. Water for livestock is stored in small reservoirs, but supplies are inadequate for significant irrigation. Irrigation water in quantity is available only along the Yellowstone River and one or two of its larger tributaries. Ground water is scarce in most of the area, but locally sand and gravel deposits and coal beds yield small to moderate amounts.

Soils: Most of the soils are Orthents, Orthids, Argids, Borolls, and Fluvents. They are medium textured to fine textured, shallow to deep, and mainly well drained. Most of these soils have a frigid temperature regime, but soils in some wide river valleys, such as the Yellowstone River Valley, have a mesic temperature regime. The nearly level to steep Torriorthents (Lisam, Cabbart, and Lambeth series), Camborthids (Yamac, Lonna, and Cambeth series), Calciorthids (Crago and Cargill series), Haplargids (Bonfri series), Natrargids (Absher series), and Argiborolls (Tanna, Ethridge, and Evanston series) are on sedimentary uplands, fans, terraces, and foot slopes. The nearly level Torrifluvents (Havre and Glendive series) are on flood plains and low stream terraces.

Potential natural vegetation: This area supports grassland vegetation. Western wheatgrass, bluebunch wheatgrass, green needlegrass, and needleandthread are dominant species. In the eastern part of the area, little bluestem replaces bluebunch wheatgrass as the dominant species.

APPENDIX B: MULTI-RESOLUTION (MRLC) LAND CHARACTERISTICS CONSORTIUM DATA DESCRIPTION

Land Cover Classes:

Water
11 Open Water
12 Perennial Ice/Snow

Developed
21 Low Intensity Residential
22 High Intensity Residential
23 Commercial/Industrial/Transportation

Barren
31 Bare Rock/Sand/Clay
32 Quarries/Strip Mines/Gravel Pits
33 Transitional

Vegetated; Natural Forested Upland
41 Deciduous Forest
42 Evergreen Forest
43 Mixed Forest

Shrubland
51 Shrubland

Non-natural Woody
61 Orchards/Vineyards/Other

Herbaceous Upland
71 Grasslands/Herbaceous

Herbaceous Planted/Cultivated
81 Pasture/Hay
82 Row Crops
83 Small Grains
84 Fallow
85 Urban/Recreational Grasses

Wetlands
91 Woody Wetlands
92 Emergent Herbaceous Wetlands

Land Cover Classification System Land Cover Class Definitions:

Water - All areas of open water or permanent ice/snow cover.

11. Open Water - areas of open water, generally with less than 25 percent or greater cover of water (per pixel).

12. Perennial Ice/Snow - All areas characterized by year-long cover of ice and/or snow.

Developed - areas characterized by high percentage (approximately 30% or greater) of constructed materials (e.g. asphalt, concrete, buildings, etc).

21. Low Intensity Residential - Includes areas with a mixture of constructed materials and vegetation. Constructed materials account for 30-80 percent of the cover. Vegetation may account for 20 to 70 percent of the cover. These areas most commonly include single-family housing units. Population densities will be lower than in high intensity residential areas.

22. High Intensity Residential - Includes heavily built up urban centers where people reside in high numbers. Examples include apartment complexes and row houses. Vegetation accounts for less than 20 percent of the cover. Constructed materials account for 80-100 percent of the cover.

23. Commercial/Industrial/Transportation - Includes infrastructure (e.g. roads, railroads, etc.) and all highways and all developed areas not classified as High Intensity Residential.

Barren - Areas characterized by bare rock, gravel, sad, silt, clay, or other earthen material, with little or no "green" vegetation present regardless of its inherent ability to support life. Vegetation, if present, is more widely spaced and scrubby than that in the "green" vegetated categories; lichen cover may be extensive.

31. Bare Rock/Sand/Clay - Perennially barren areas of bedrock, desert, pavement, scarps, talus, slides, volcanic material, glacial debris, and other accumulations of earthen material.

32. Quarries/Strip Mines/Gravel Pits - Areas of extractive mining activities with significant surface expression.

33. Transitional - Areas of sparse vegetative cover (less than 25 percent that are dynamically changing from one land cover to another, often because of land use activities. Examples include forest clearcuts, a transition phase between forest and agricultural land, the temporary clearing of vegetation, and changes due to natural causes (e.g. fire, flood, etc.)

Forested Upland - Areas characterized by tree cover (natural or semi-natural woody vegetation, generally greater than 6 meters tall); Tree canopy accounts for 25-100 percent of the cover.

41. Deciduous Forest - Areas dominated by trees where 75 percent or more of the tree species shed foliage simultaneously in response to seasonal change.

42. Evergreen Forest - Areas characterized by trees where 75 percent or more of the tree species maintain their leaves all year. Canopy is never without green foliage.

43. Mixed Forest - Areas dominated by trees where neither deciduous nor evergreen species represent more than 75 percent of the cover present.

Shrubland - Areas characterized by natural or semi-natural woody vegetation with aerial stems, generally less than 6 meters tall with individuals or clumps not touching to interlocking. Both evergreen and diciduous species of true shrubs, young trees, and trees or shrubs that are small or stunted because of environmental conditions are included.

51. Shrubland - Areas dominated by shrubs; shrub canopy accounts for 25-100 percent of the cover. Shrub cover is generally greater than 25 percent when tree cover is less than 25 percent. Shrub cover may be less than 25 percent in cases when the cover of other life forms (e.g. herbaceous or tree) is less than 25 percent and shrubs cover exceeds the cover of the other life forms.

Non-natural Woody - Areas dominated by non-natural woody vegetation; non-natural woody vegetative canopy accounts for 25-100 percent of the cover. The non-natural woody classification is subject to the availability of sufficient ancillary data to differentiate non-natural woody vegetation from natural woody vegetation.

61. Orchards/Vineyards/Other - Orchards, vineyards, and other areas planted or maintained for the production of fruits, nuts, berries, or ornamentals.

Herbaceous Upland - Upland areas characterized by natural or semi- natural herbaceous vegetation; herbaceous vegetation accounts for 75-100 percent of the cover.

71. Grasslands/Herbaceous - Areas dominated by upland grasses and forbs. In rare cases, herbaceous cover is less than 25 percent, but exceeds the combined cover of the woody species present. These areas are not subject to intensive management, but they are often utilized for grazing.

Planted/Cultivated - Areas characterized by herbaceous vegetation that has been planted or is intensively managed for the production of food, feed, or fiber; or is maintained in developed settings for specific purposes. Herbaceous vegetation accounts for 75-100 percent of the cover.

81. Pasture/Hay - Areas of grasses, legumes, or grass-legume mixtures planted for livestock grazing or the production of seed or hay crops.

82. Row Crops - Areas used for the production of crops, such as corn, soybeans, vegetables, tobacco, and cotton.

83. Small Grains - Areas used for the production of graminoid crops such as wheat, barley, oats, and rice

84. Fallow - Areas used for the production of crops that are temporarily barren or with sparse vegetative cover as a result of being tilled in a management practice that incorporates prescribed alternation between cropping and tillage.

85. Urban/Recreational Grasses - Vegetation (primarily grasses) planted in developed settings for recreation, erosion control, or aesthetic purposes. Examples include parks, lawns, golf courses, airport grasses, and industrial site grasses.

<u>Wetlands</u> - Areas where the soil or substrate is periodically saturated with or covered with water as defined by Cowardin et al.

91. Woody Wetlands - Areas where forest or shrubland vegetation accounts for 25-100 percent of the cover and the soil or substrate is periodically saturated with or covered with water.

92. Emergent Herbaceous Wetlands - Areas where perennial herbaceous vegetation accounts for 75-100 percent of the cover and the soil or substrate is periodically saturated with or covered with water.

APPENDIX C: MONTANA NARRATIVE WATER QUALITY STANDARDS

Montana Narrative Water Quality Standards (ARM 17.30.637)

(1) State surface waters must be free from substances attributable to municipal, industrial, agricultural practices or other discharges that will:

(a) Settle to form objectionable sludge deposits or emulsions beneath the surface of the water or upon adjoining shorelines;

(b) Create floating debris, scum, a visible oil film (or be present in concentrations at or in excess of 10 milligrams per liter) or globules of grease or other floating materials;

(c) Produce odors, colors or other conditions as to which create a nuisance or render undesirable tastes to fish flesh or make fish inedible;

(d) Create concentrations or combinations of materials which are toxic or harmful to human, animal, plant or aquatic life; and

(e) Create conditions which produce undesirable aquatic life.

(2) No wastes may be discharged and no activities conducted such that the wastes or activities, either alone or in combination with other wastes or activities, will violate, or can reasonably be expected to violate, any of the standards.

(3) Leaching pads, tailing ponds, or water, waste, or product holding facilities must be located, constructed, operated and maintained in such a manner and of such materials so as to prevent the discharge, seepage, drainage, infiltration, or flow which may result in the pollution of surface waters. The department may require that a monitoring system be installed and operated if the department determines that pollutants are likely to reach surface waters or present a substantial risk to public health.

(a) Complete plans and specifications for proposed leaching pads, tailing ponds, or water, waste, or product holding facilities utilized in the processing of ore must be submitted to the department no less than 180 days prior to the day on which it is desired to commence their operation.

(b) Leaching pads, tailing ponds, or water, waste, or product holding facilities operating as of the effective date of this rule must be operated and maintained in such a manner so as to prevent the discharge, seepage, drainage, infiltration or flow which may result in the pollution of surface waters.

(4) Dumping of snow from municipal and/or parking lot snow removal activities directly into surface waters or placing snow in a location where it is likely to cause pollution of surface waters is prohibited unless authorized in writing by the department.

(5) Until such time as minimum stream flows are established for dewatered streams, the minimum treatment requirements for discharges to dewatered receiving streams must be no less than the minimum treatment requirements set forth in ARM 17.30.635(2) and (3).

(6) Treatment requirements for discharges to ephemeral streams must be no less than the minimum treatment requirements set forth in ARM 17.30.635(2) and (3). Ephemeral streams are subject to ARM 17.30.635 through 17.30.637, 17.30.640, 17.30.641, 17.30.645 and 17.30.646 but not to the specific water quality standards of ARM 17.30.620 through 17.30.629.

(7) Pollution resulting from storm drainage, storm sewer discharges, and non-point sources, including irrigation practices, road building, construction, logging practices, over-grazing and other practices must be eliminated or minimized as ordered by the department.

(8) Application of pesticides in or adjacent to state surface waters must be in compliance with the labeled direction, and in accordance with provisions of the Montana Pesticides Act (Title 80, chapter 8, MCA) and the Federal Environmental Pesticides Control Act (7 USC 136, et seq., (Supp. 1973) as amended).

Excess pesticides and pesticide containers must not be disposed of in a manner or in a location where they are likely to pollute surface waters.

(9) No pollutants may be discharged and no activities may be conducted which, either alone or in combination with other wastes or activities, result in the total dissolved gas pressure relative to the water surface exceeding 110% of saturation.

APPENDIX D: MDEQ PROPOSED EC AND SAR STANDARDS

August 29, 2002 Standards (Old Proposed Standards)

The proposed SAR standard varies depending on the salinity of the water. Under the proposed standards, the instantaneous SAR in a waterbody may not exceed the value given by the equation [(EC*0.0071) – 2.475]. At an EC of 350 µS/cm or less, the formula indicates that the allowable SAR is less than zero. Because of this nonsensical result, the formula does not apply when the EC is 350 µS/cm or less. When the formula given above for calculating the proposed SAR standard results in a value greater than 5, the SAR standard is 5. The proposed formula and conditions for SAR apply year-round to all waters in the Rosebud Creek watershed.

Table D-1. August 29, 2002 proposed EC standards for agricultural uses (µS/cm).

Waterbody	April 1–October 31 (Growing Season)	November 1–March 31 (Non-growing Season)
Rosebud Creek, Main stem	1,000	2,000
Rosebud Creek, Tributaries	500	2,000

December 6, 2002 Standards (New Proposed Standards)

Table D-2. December 6, 2002 proposed EC standards for agricultural uses (µS/cm).

Waterbody	March 2–October 31 (Growing Season)	November 1–March 1 (Non-growing Season)
Rosebud Creek, Main stem	1,000	2,000
Rosebud Creek, Tributaries	500	500

Table D-3. December 6, 2002 proposed SAR standards for agricultural uses.

Waterbody	March 2–October 31 (Growing Season)	November 1–March 1 (Non-growing Season)
Rosebud Creek, Main stem	3.5	5.0
Rosebud Creek, Tributaries	5.0	5.0

APPENDIX E: COMPARISON OF THE PROPOSED EC AND SAR STANDARDS

Montana Proposed EC and SAR Criteria

On August 29, 2002, the Montana Board of Environmental Review proposed numeric water quality standards for the Tongue River and the Powder River, Little Powder River, Rosebud Creek and their tributaries for electrical conductivity (EC) and sodium adsorption ratio (SAR). All available water quality data are compared to these proposed standards in the main text of this document. On December 6, 2002, the Montana Board of Environmental Review instructed DEQ to prepare a supplemental notice of rulemaking regarding the adoption of numeric water quality standards for the Tongue River, Powder River, Little Powder River, Rosebud Creek and their tributaries for EC and SAR. This supplemental notice included a revised set of numeric criteria for EC and SAR. Insufficient time was available to modify this document to include consideration of these revised criteria. Major changes included in the December 6 proposed standards are described below.

- The definition of the growing season is now March 2 – October 31. The growing season was previously defined as April 1 – October 31.
- SAR standards are now fixed numbers. SAR standards were previously calculated using a formula that incorporated the EC at the time of sampling.
- The non-growing season EC criterion for Rosebud Creek tributaries is now 500 µS/cm.
- Both the EC and SAR standards are now based on monthly averages. Standards were previously treated as maximum allowable values for single samples.

A preliminary analysis of the December 6, 2002 standards is presented in the tables and figures below. These are referred to as the *"new proposed standards"* in the figures. Further analysis and discussion of these results will be presented in the final TMDL document.

Electrical Conductivity (EC)

Table E-1. Summary of EC exceedances, lower Rosebud Creek.

Season	Salinity Criteria (µS/cm)[a]	# of Averaging Periods	Total # of Exceedances	Percent Exceeding	# of Averaging Periods, 1996-2002	Total # of Exceedances, 1996-2002	Percent Exceeding, 1996-2002
Growing Season[b]	1,000	150	130	87%	29	28	97%
Non-Growing Season	2,000	68	28	41%	8	5	63%

[a]An average value per month per station not to be exceeded.
[b]Growing season is March 2 – October 31.

Table E-2. Summary of EC exceedances, middle Rosebud Creek.

Season	Salinity Criteria (µS/cm)[a]	# of Averaging Periods	Total # of Exceedances	Percent Exceeding	# of Averaging Periods, 1996-2002	Total # of Exceedances, 1996-2002	Percent Exceeding, 1996-2002
Growing Season[b]	1,000	186	157	84%	26	25	96%
Non-Growing Season	2,000	95	2	2%	10	0	0%

[a]An average value per month per station not to be exceeded.
[b]Growing season is March 2 – October 31.

Table E-3. Summary of EC exceedances, upper Rosebud Creek.

Season	Salinity Criteria (µS/cm)[a]	# of Averaging Periods	Total # of Exceedances	Percent Exceeding	# of Averaging Periods, 1996-2002	Total # of Exceedances, 1996-2002	Percent Exceeding, 1996-2002
Growing Season[b]	1,000	137	26	19%	21	2	10%
Non-Growing Season	2,000	52	0	0%	6	0	0%

[a]An average value per month per station not to be exceeded.
[b]Growing season is March 2 – October 31.

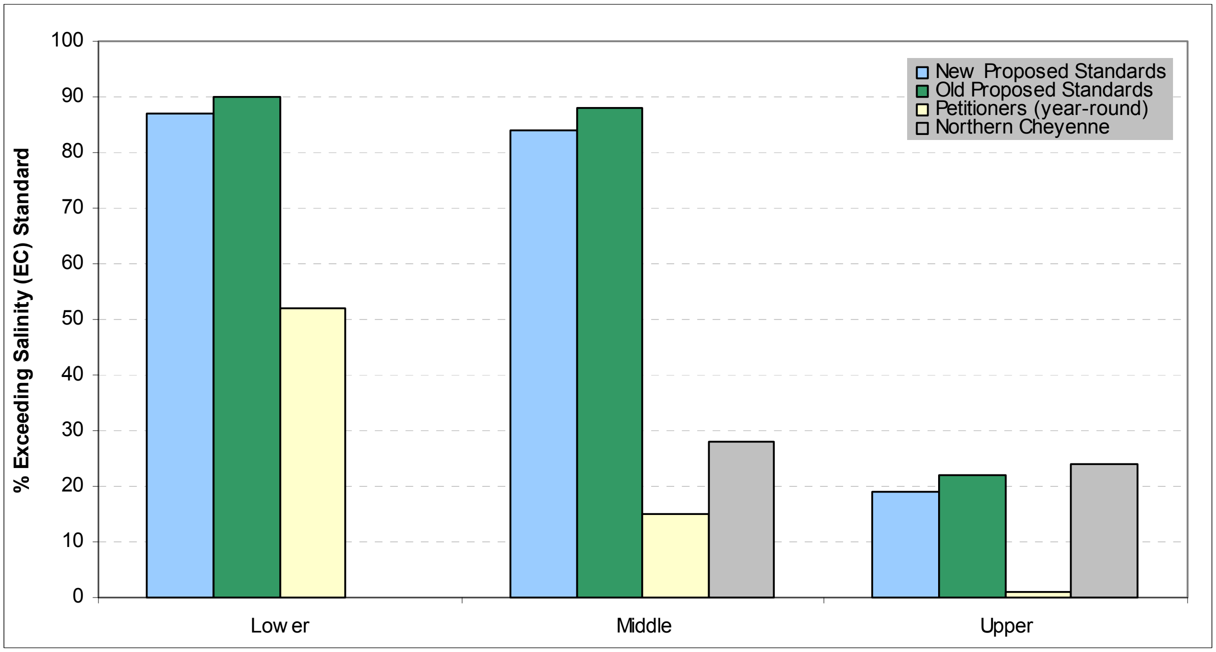

Figure E-1. Summary of salinity (EC) exceedances for Rosebud Creek (growing season).

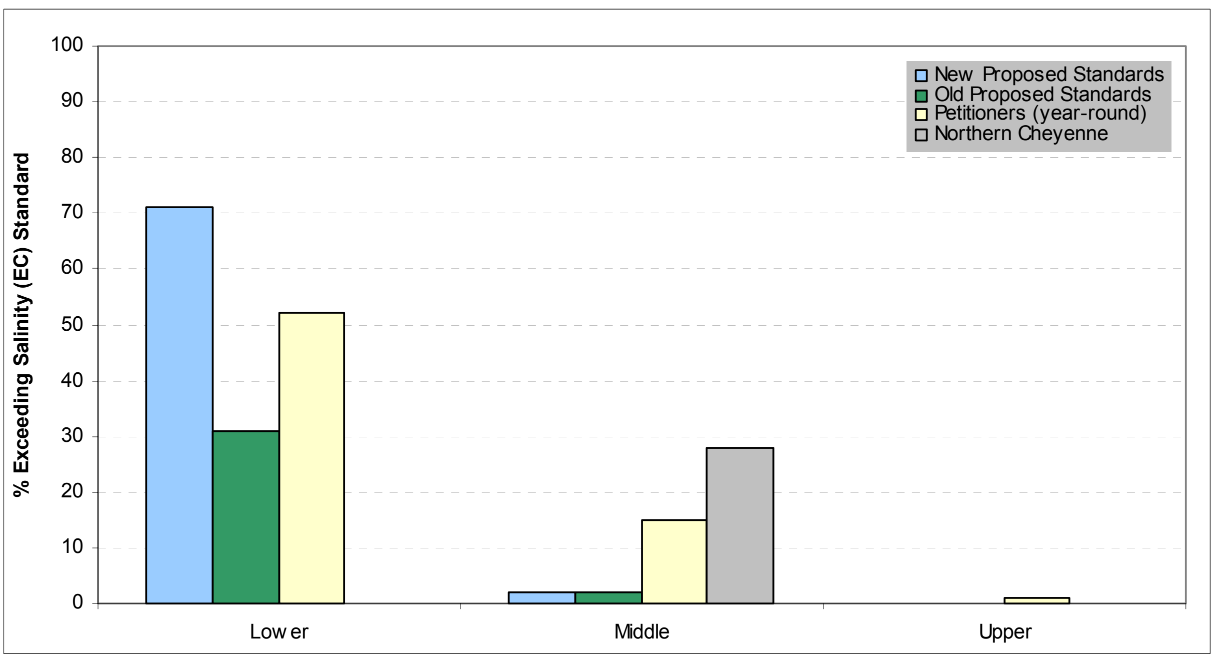

Figure E-2. Summary of salinity (EC) exceedances for Rosebud Creek (non-growing season).

SAR

Table E-4. Summary of SAR exceedances, lower Rosebud Creek.

Season	SAR Criteria[a]	# of Averaging Periods	Total # of Exceedances	Percent Exceeding	# of Averaging Periods, 1996-2002	Total # of Exceedances, 1996-2002	Percent Exceeding, 1996-2002
Growing Season[b]	3.5	94	36	38%	3	2	67%
Non-Growing Season	5.0	32	1	3%	1	NA	NA

[a]An average value per month per station not to be exceeded.
[b]Growing season is March 2 – October 31.

Table E-5. Summary of SAR exceedances, middle Rosebud Creek.

Season	SAR Criteria[a]	# of Averaging Periods	Total # of Exceedances	Percent Exceeding	# of Averaging Periods, 1996-2002	Total # of Exceedances, 1996-2002	Percent Exceeding, 1996-2002
Growing Season[b]	3.5	117	3	3%	0	NA	NA
Non-Growing Season	5.0	59	0	0%	0	NA	NA

[a]An average value per month per station not to be exceeded.
[b]Growing season is March 2 – October 31.

Table E-6. Summary of SAR exceedances, upper Rosebud Creek.

Season	SAR Criteria[a]	# of Averaging Periods	Total # of Exceedances	Percent Exceeding	# of Averaging Periods, 1996-2002	Total # of Exceedances, 1996-2002	Percent Exceeding, 1996-2002
Growing Season[b]	3.5	44	0	0%	0	NA	NA
Non-Growing Season	5.0	18	0	0%	0	NA	NA

[a]An average value per month per station not to be exceeded.
[b]Growing season is March 2 – October 31.

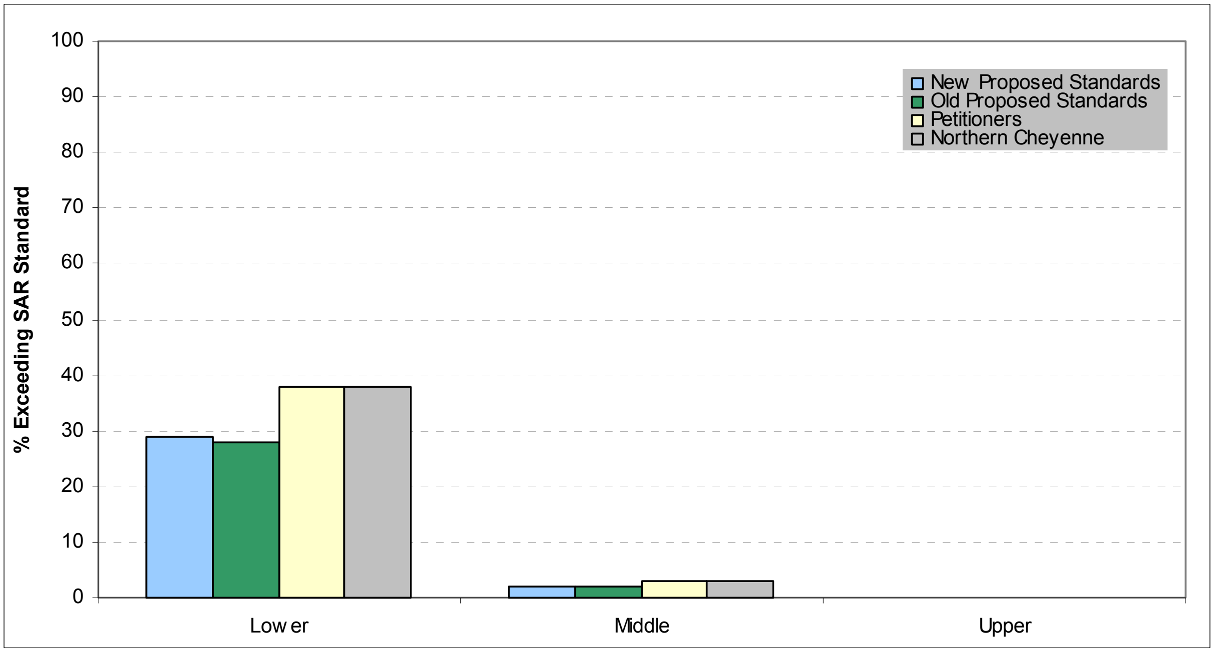

Figure E-3. Summary of SAR exceedances for Rosebud Creek (year-round).

APPENDIX F: COEFFICIENTS FOR CALCULATING METALS STANDARDS FOR SURFACE WATERS

COEFFICIENTS FOR CALCULATING METALS STANDARDS FOR SURFACE WATERS IN MONTANA

Table F-1. Coefficients for calculating metals standards in Montana.

Parameter	ma	ba	mc	bc
Cadmium	1.0166	-3.924	0.7409	-4.719
Copper	0.9422	-1.700	0.8545	-1.702
Chromium (III)	0.819	3.7256	0.819	0.6848
Lead	1.273	-1.46	1.273	-4.705
Nickel	0.846	2.255	0.846	0.0584
Silver	1.72	-6.52	—	—
Zinc	0.8473	0.884	0.8473	0.884

Note: If the hardness is < 25 mg/L as $CaCO_3$, the number 25 must be used in the calculation. If the hardness is greater than or equal to 400 mg/L as $CaCO_3$, 400 mg/L must be used in the calculation.

Acute Standard = exp.{ma[ln(Hardness)] + ba}
Chronic Standard = exp.{mc[ln(Hardness)] + bc}

USEPA STANDARDS

Equations for the calculation of acute and chronic standards

$$CMC_{(dissolved)} = CF \times e^{m_a(\ln hardness)+b_a}$$

$$CCC_{(dissolved)} = CF \times e^{m_c(\ln hardness)+b_c}$$

Table F-2. USEPA equations and conversion factors for metals.

Parameter	m_a	b_a	m_c	b_c	Conversion Factors (CF)	
					Acute	Chronic
Cadmium	1.128	-3.6867	0.7852	-2.715	1.136672-[ln (hardness)(0.041838)]	1.101672-[ln (hardness)(0.041838)]
Chromium III	0.8190	3.7256	0.8190	0.6848	0.316	0.860
Copper	0.9422	-1.700	0.8545	-1.702	0.960	0.960
Lead	1.273	-1.460	1.273	-4.705	1.46203-[ln (hardness)(0.145712)]	1.46203-[ln (hardness)(0.145712)]
Nickel	0.8460	2.255	0.8460	0.0584	0.998	0.997
Silver	1.72	-6.52	—	—	0.85	—
Zinc	0.8473	0.884	0.8473	0.884	0.978	0.986